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A. H. G. ALSTON, B.A. (Oxon)

Systematic Botanist, Department of Agriculture, Ceylon

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The Ceylon Species of *Glochidion*

BY

A. H. G. Alston, B.A. (Oxon)

Systematic Botanist, Department of Agriculture, Ceylon

WITH ONE PLATE

The genus *Glochidion* was founded by Forster (2) in 1776 with *G. australe* as the type species. It was reduced to *Phyllanthus* by Mueller (12) but re-instated by Beddome (1). The species are found throughout Tropical Asia and Oceania, but are usually confined to small areas. The Ceylon species are all endemic.

The species are under-shrubs or small trees found commonly in the forests of the Island, except *G. zeylanicum* and *G. acutifolium* which are found in open grassy or boggy places. The plants usually flower and fruit more freely when growing on the borders of jungles. They all seem to be called Huna-Kirilla by the Sinhalese sometimes with prefixes like Bu (hairy)-Hunu-Kirilla, Diya (water)-Hunu-Kirilla.

The two sections *Euglochidion* and *Hemiglochidion* are readily separated by the fruits, which are multilocular and obscurely lobed in the former, trilocular and 3-6-lobed in the latter. The former is represented in Ceylon by *G. zeylanicum* only, the other species being all referable to *Hemiglochidion*.

The pubescence has been found almost worthless as a specific distinction and the classification is based chiefly on the size and form of the stigma. The size is, however, variable in *G. Moonii* and *G. montanum*. The lobes are incurved when young but later become spreading. *G. montanum*, *G. Gardneri*, *G. acutifolium* and *G. Moonii* are not distinguishable in dried specimens by satisfactory characters, but in the field *G. Moonii* has bullate leaves and a green-veined perianth, in *G. montanum* and *G. acutifolium* the leaves are flat and the perianth of *G. montanum* has red veins. The painting of *G. Gardneri* in the Peradeniya Herbarium shows flat leaves and a green perianth. Usually plants growing outside or on the margin of the jungle are more hairy than those found inside.

KEY TO THE SPECIES

Capsule 5-8 locular, very obscurely lobed ;
 stam. 5-6 ; style short, caducous.
 (*Euglochidion*) 1. *G. zeylanicum*.

Capsule 3-locular, lobed ; stam. 3-4 ; style
 subsistent (*Hemiglochidion*) :

Style not exerted ; leaves very
 coriaceous ; stam. 4 2. *G. coriaceum*.

Style exerted ; stam. 3 :

Style less than twice as long as the
 perianth :

Fruit $\frac{1}{4}$ - $\frac{1}{2}$ in. ; lvs. usually acuminate :

Female fls. subsessile ; lvs. un-
 equal sided ; perianth of male fls.

5-lobed 3. *G. pycnocarpum*.

Female fls. stalked ; lvs. unequal
 sided ; perianth of male fls.

6-lobed 4. *G. stellatum*.

Fruit nearly $\frac{1}{2}$ in. ; lvs. not

acuminate 5. *G. pachycarpum*.

Style twice as long as the peri-
 anth ; lvs. rarely acuminate, not
 bullate ; fls. sessile ; perianth with

red midribs 6. *G. montanum*.

Fls. stalked ; secondary nerves
 strongly arcuate 7. *G. nemorale*.

Fls. subsessile ; perianth with
 green midribs, secondary nerves
 not markedly arcuate :

Lvs. elliptic ; not bullate ;
 style glabrous ; perianth pubes-

cent 8. *G. Gardneri*.

Lvs. lanceolate :

Style and perianth glabrous ;

lvs. flat 9. *G. acutifolium*.

Style and perianth pubes-
 cent ; lvs. bullate 10. *G. Moonii*.

1. *Glochidion zeylanicum* A. Juss. Tent. Euphorb. p. 107 (1824) ;
 Thw. Enum. p. 285 (1861) ; C.P. 2149 ; Bedd. For. Man. p. 1921 (1873 ?) ;
 Hk. f. in Fl. Brit. Ind. V, p. 310 (1890) pp. ; Trim. Fl. Ceyl. IV, p. 28
 (1898) ; Pearson in Journ. Linn. Soc. Bot. XXXIII, p. 355 (1900) ; F.

Lewis Trees and Fl. Plants of the West and Sab. Provs. p. 137 (1902) pp. *Bradleia zeylanica* Gaertn. Fruct. II, p. 128 t. 129 (1791). *Phyllanthus zeylanicus* Muell. Arg. in DC. Prodr. XV, 2, p. 281 (1866) pp. non. Linnaea XXXII, p. 49. *Diasperus zeylanicus* O. Ktze. Rev. Gen. p. 601 (1891).

Moist low-country up to 4,000 ft. common. Without exact locality, *Leschenault* (fide Mueller); 3,800 ft., *Pearson* 869 (fide Pearson); *Pera-deniya*, *Gardner*! Ambagamuva, 1852, *Thwaites*! Pasdun Korale, Dec. 1853. *Thwaites*! Diyatalava camp, 3,800 ft. 23.v.06, *Smith*! in bog near Ratnapura, 1. iv. 27 *Alston*!

Var ? *tomentosum* Hk. f. in Trim. Fl. Ceyl. IV, p. 29 (1898). *G. zeylanicus* β. Thw. Enum. p. 285 (1861), C.P. 3432. *Phyllanthus zeylanicus* var. *tomentosus* Trim. Syst. Cat. p. 79 (1885) nomen.

Punapala, Kukul Korale, 23.iv.55, *Thwaites*! Rayigam Korale, Sept., 1864, *Thwaites*! on patanas, Hunasgiriya, 24.vi.26, *Alston* 328! on patanas, Bulutota, 31.iii.27, *Alston*! in bog near Ratnapura, 1.iv.27, *Alston*!

At Ratnapura both varieties were found growing together, variety *tomentosum* was then the commonest plant and had larger leaves than the type.

Endemic? Several species appear to have been included under this name in the Fl. Brit. Ind. Maingay 1357 has been separated as *G. Maingayi* Gage (3) and *G. obliquum* Blume is probably distinct. *Thwaites* (16) quotes for his var β. "Amherst, Falconer 845" which is *G. silheticum* (*Phyllanthus silheticus* Muell. Arg.)

Gaertner (4) gives the name Gunu-Kirielle and states that the type is in the seed collection of the Leyden Herbarium. F. Lewis (9) describes his plant as having a persistent style, which must refer to some other species, perhaps *G. acutifolium*.

2. *G. coriaceum* Thw. Enum. p. 285 (1861) pp., C.P. 3016 non Muell. *G. brachylobum* Muell. Arg. in Linnaea XXXII, p. 62 (1863); Bedd. For. Man. p. 192 (1873 ?); Hk. f. in Fl. Brit. Ind. V, p. 313 (1890); Trim. Fl. Ceyl. IV, p. 29 (1898). *Phyllanthus brachylobus* Muell. Arg. in Flora XLVIII, p. 373 (1865); in DC. Prodr. XV, 2, p. 288 (1866). *Diasperus brachylobus* O. Ktze. Rev. Gen. p. 598 (1891).

Moist region in lower montane zone; rather rare. Ambagamuva, Mar. 1853, *Thwaites*! (type); in jungle Bulutota, 31.iii.27, *Alston*!

Distinguished by the coriaceous leaves and very short style. *Thwaites* (16) quotes C.P. 3016, 342, and 2529 for this, of these C.P. 2529 is *G. pycnocarpum* Bedd., C.P. 342 is here referred to *G. montanum* Thw., the name *G. coriaceum* Thw. being restricted to C. P. 3016, which is the

most coriaceous specimen, the only one to which "style crasso, brevi, oblongo vel suborbiculari" applies, and Thwaites first citation. C.P. 2529 was the first specimen collected by Thwaites though it is cited last. Unfortunately Mueller and other authors used the name *G. coriaceum* for C.P. 342.

3. ***Glochidion pycnocarpum*** Bedd. For. Man. p. 194 (1873 ?) ; Hk. f. in Fl. Brit. Ind. V, p. 315 (1890). excl. var. *elliptica* ; Trim. Fl. Ceyl. IV, p. 29 (1898.) *G. coriaceum* Thw. Enum. p. 285 (1861) pp., C.P. 2529 ; Trim. Fl. Ceyl. IV, p. 30 (1898) pp. non. Muell. *Phyllanthus pycnocarpus* Muell. Arg. in Flora XLVIII, p. 386 (1865) ; in DC. Prodr. XV, 2, 304 (1866). *Diasperus pycnocarpus* O. Ktze. Rev. Gen. p. 600 (1801).

Montane zone ; rather rare ? "Wallapodo," 19.ix.51, *Thwaites* ! 131 ! (type) ; Hunasgiriya, Jan. 1854, *Thwaites* ? Hakgala, 1890, *Trimen* ! 23.v.11, *J. M. Silva* ! Mar. 1922, *A. de Alwis* ! without exact locality, *Gardner* (fide Hooker).

Mueller (11) quotes only C.P. 2529 under which number Thwaites presumably first distributed the "Wallapodo" plant for which his field number was 131 and later specimens from Hunasgiriya. It is probable that all the Peradeniya specimens are from "Wallapodo," a locality I do not know unless Vallahagoda was intended. The commonest *Glochidion* on Hunasgiriya is *G. montanum* which Thwaites only knew from Uva.

4. ***Glochidion stellatum*** Bedd. For. Man. p. 194 (1873 ?) pp. *Phyllanthus stellatus* Retz. Obs. Bot. V, p. 29 (1789) ; Moon. Cat. p. 65 (1824) ; Muell. Arg. in DC. Prodr. XV, 2, p. 305 (1862) pp. *Phyllanthus laurifolius* Thunb. Mus. Upsal. X, p. 156 (1791) ; Fl. Ceil. p. 8 (1825) ; Juel. Pl. Thunb. p. 195 (1918). *Gynoon rigidum* A. Juss. Tent. Euphorb. p. 107 (1824). *G. triandrum* Wt. Ic. t. 1908 (1852) plate. *G. Jussieuanum* Wt. l.c. text ; Bedd. For. Man. p. 194 (1873 ?). *Glochidion Jussieuanum* Thw. Enum. p. 285 (1861) pp., C.P. 2561. *G. rigidum* Muell. Arg. in Linnaea XXXII, p. 67 (1863) ; Hk. f. in Fl. Brit. Ind. V, p. 320 (1890) ; Trim. Fl. Ceyl. IV, p. 50 (1898). *G. Thwaitesii* Muell. Arg. in Linnaea XXXII, p. 66 (1863). *Phyllanthus Jussieuanus* Muell. Arg. in Flora XLVIII, p. 386 (1865) ; in DC. Prodr. XV, 2, p. 304 (1866). *Diasperus stellatus* and *Jussieuanus* O. Ktze. Rev. Gen. pp. 597 and 599 (1891). *Glochidion* sp. Willis in Ann. Perad. III, p. 285 (1906).

Low country ; common. Without exact locality, *Koenig* (type) (fide Retzius, *Trimen*, and *Mueller*), *Thunberg* (fide *Mueller*), *Wight* (fide *Mueller*), *Gardner* ? ; Kalutara, *Moon* (fide *Moon*) ; Central Province, *Thwaites* ! Bibile, Feb. 1858, *Thwaites* ! Veddagala, S.P., Mar. 1881,

Trimen ! Nilgala, Uva, Jan. 1888. *Trimen* ! near Bentota Mar. 1887, *Trimen* ! top of Ritigala, N.C.P., 24.iii.05, *Willis* ! Hiyare, Calle, 18.viii.26, *Alston* 324 ! between Nugatenne and Madugoda, 7.ix.26, *Alston* 325 ! Illukumbara, Lagalla 31.x.26, *J. M. Silva* !

Distinguishable by its stalked female flowers and fruits. The plant thought by Willis to be a new species confined to the summit of Ritigala is evidently this. There is a specimen of Stocks Law 33, mentioned by Willis (22) in the Peradeniya Herbarium, but it has a totally different style from *G. stellatum* and is probably the *G. fagifolium* of the Fl. Brit. Ind. A specimen from Sudugala Kande collected by Trimén is here referred to *G. pachycarpum*. Mueller (11) distinguished *P. Jussieuanus* as having the leaves darker on the upper surface. Moon (10) gives the Sinhalese name Diya-hunu-kirilla but he may have intended some other species.

5. *Glochidion pachycarpum* sp. nov. *G. Jussieuanum* var. Thw. Enum p. 285 (1861), C.P. 2560. *G. pycnocarpum* var. *elliptica* Hk. f. in Fl. Brit. Ind. V, p. 316 (1890) ; Trim. Fl. Ceyl. IV, p. 29 (1898).

Arbor parva ? ; rami teretes, flavo-brunnei, semper glabri ; ramuli alternantes, plerumque simplices, breves, graciles, angulati. Foliorum squamae minutae, subtriangulares ; lamina obovato-elliptica, tenuiter coriacea, 3-6 cm. longa, $1\frac{1}{2}$ -3 cm. lata, in siccitate nigrescentia vel glaucescentia, apice obtusa vel leviter emarginata, margine integro, basi cuneata, leviter decurrens, aequilaterale ; pagina superior obscura, glabra, nervis tertiariis obscuris ; pagina inferior nervis tertiariis reticulatis, validis ; nervi laterales in costae mediae utraque parte circiter 5, arcuati, et propter marginem anastomosantes ; petiolus 2.5-5 mm. longus ; stipulae minutae, tringulares, glabrae, subpersistentes, in siccitate flavo-brunneae. Flores in glomerulis axillaribus congregati, in siccitate nigrescentes, in axillis singulis flores masculini vel feminini. Flores masculini pedicellati, pedicellis 3 mm. longis ; calyx 6-partitus ; sepala biseriata, erecta, ovata, glabra, 25 mm. longa. Flores feminini sessili, in nodulis axillaribus minutissimis bracteolatis dispositi ; bracteolae subtriangulares, in siccitate nigrescentes ; calyx 2 mm. longus, ad medium 6-lobatus, sepalis biseriatis, glabris ; stigma 2 mm. longa ; styli conici, incumbentes. Fructus infra calycem persistentem pedicellatus, pedicello 1.5 mm. longo, 6-lobatus, 1 cm. altus, 1.25 cm. latus, glaber.

Lower montane zone ; rare ? without exact locality, *Gardner* ! Central Province, Sept. 1866, *Thwaites* ! Sudugala Kande, Lagalla, Sept. 1893, *Trimén* ! (type).

Readily distinguished by the large fruit.

6. **Glochidion montanum** Thw. Enum. p. 286 (1861), C.P. 3133; Hk. f. in Fl. Brit. Ind. V, p. 323 (1890); Trim. Fl. Ceyl. IV, p. 31 (1898); Pearson in Journ. Linn. Soc. Bot. XXXIV, p. 355 (1890). *Phyllanthus symplocoides* Muell. Arg. in DC. Prodr. XV, 2, p. 311 (1866). *Glochidion symplocoides* Bedd. For. Man. p. 195 (1873 ?). *Diasperus symplocoides* O. Ktze. Rev. Gen. p. 597 (1891).

Lower montane zone; rather common.

The typical form has the leaves pubescent beneath.

Attampitiya, Uva, Apr. 1854, *Thwaites*! (type); Rassagala, Balangoda, Sept. 1895, *Trimen*! Knuckles, *J. M. Silva*! Hunasgiriya, 20.ii.27, *Alston*!

Forma **subglabra** (Trim.) *G. Moonii* Thw. Enum. p. 286 (1861) pp. C.P. 68. var. *subglabra* Hk. f. in Trim. Fl. Ceyl. IV, p. 31 (1898). *Phyllanthus pubescens* var. *subglabra* Trim. Syst. Cat. p. 79 (1885) nomen,

Leaves glabrous beneath.

Attampitiya, Uva, Apr. 1854, *Thwaites*! Maturata, 1853, *Thwaites*! Bilahul oya, Balangoda, 26.ii.81, *Trimen*! Hiniduma, Feb. 1923, *Livera*! Rangala, 29.viii.26, *Alston*! Hunasgiriya, 24.vi.26, *Alston*!

Some of these specimens may be referable to *G. Moonii*, but the specimens collected by the author had not bullate leaves and the Rangala specimen at least had the red perianth midribs characteristic of *G. montanum*.

Forma **atrichostigma** forma nov.

Stigma glabrous.

Near Passara, Uva, Jan. 1888, *Trimen*! Hakgala, March 1922, *A. de Alwis*!

Var ? **glaberrima** var. nov. *G. coriaceum* Thw. Enum. p. 285 (1861) pp., C.P. 342; Bedd. For. Man. p. 194 (1873 ?); Hk. f. in Fl. Brit. Ind. V, p. 321 (1890); Trim. Fl. Ceyl. IV, p. 30 (1898) pp.; Pearson in Journ. Linn. Soc. Bot. XXXIV, p. 356 (1900). *Phyllanthus coriaceus* Muell. Arg. in DC. Prodr. XV, 2, p. 304 (1866).

Whole plant glabrous.

Central Province *Thwaites*! Hevaheta, Oct. 1852, *Thwaites*! Ambagamuva, March 1858, *Thwaites*! without exact locality, 3,800 ft., Pearson 881 (fide Pearson); between Lagalla and Pallegama, 30.x.26, *J. M. Silva*!

Trimen (19) gives Hakgala but the specimen is *G. pycnocarpum* Bedd. The leaves are sometimes slightly bullate. This variety may prove to be specifically distinct.

7. **Glochidion nemorale** Thw. Enum. p. 286 (1861), C.P. 3015; Hk. f. in Fl. Brit. Ind. V, p. 324 (1890); Bedd. For. Man. p. 195 (1873 ?)

(*memorale*); Trim. Fl. Ceyl. IV, p. 31 (1898). *Phyllanthus nemoralis* Muell. Arg. in DC. Prodr. XV, 2, p. 312 (1866). *Diasperus nemoralis* O. Ktze. Rev. Gen. p. 600 (1891).

Moist region below 1,000 ft., rather common? Pasdun Korale, Dec. 1865, *Thwaites*! (type); Sabaragamuva, Sept. 1865, *Thwaites*! Kuruwita, June, 1895, *Trimen*! between Kuruwita and Eratne, 18.ii.27, *J. M. Silva* 146! Dotalugala Kande, 1.v.27, *J. M. Silva*!

This species is well distinguished by the oblique lateral veins, numerous stalked female flowers, and long style.

8. **Glochidion Gardneri** Thw. Enum. p. 286 (1861), C.P. 3156; Hk. f. in Fl. Brit. Ind. V, p. 325 (1890); Trim. Fl. Ceyl. IV, p. 31 (1898). *Phyllanthus leptogynus* Muell. Arg. in Flora XLVIII, p. 389 (1865); in DC. Prodr. XV, 2, p. 312 (1866). *Glochidion leptogynum* Bedd. For. Man. p. 195 (1873?). *Diasperus Gardneri* O. Ktze. Rev. Gen. p. 597 (1891).

Moist region; rare. Central Province, *Gardner*, (type) (fide *Thwaites* and *Hooker*), *Walker* (fide *Hooker*); Peradeniya Gardens, 3.iii.62, *Thwaites*!

9. **Glochidion acutifolium** sp. nov. *G. Gardneri* var. β . Thw. Enum p. 286 (1860); Hk. f. in Fl. Brit. Ind. V, p. 326 (1890). var. *acuminata* Trim. Fl. Ceyl. IV, p. 31 (1898).

Frutex 1 m. altus; rami teretes, brunnei, glabri, 4 mm. crassi, sine foliis; internodia 4 cm. longa; ramuli simplices, graciles, leviter angulati, glauci, glabri; internodia 1.5 cm. longa. Foliorum lamina lanceolata, tenuiter coriacea, plerumque circiter 8 cm. longa, 2-2.5 cm. lata, rarius usque ad 17 cm. longa, 5 cm. lata, in siccitate nigrescentia vel. glaucescentia, apice acute acuminata, margine integro, basi cuneata, plerumque inaequilaterale; pagina superior obscura, nervis lateralibus validis; pagina inferior obscura vel nitida, nervis tertiariis subvalidis, subparallelis; nervi laterali in costa mediae utraque parte 5-6, excurvati et propter marginem anastomosantes; petiolus 2.5-4 mm. longus; stipulae subpersistentes, subulatae, acuminatae, glabrae. Flores in glomerulis axillaribus congregati; in axillis singulis flores plerumque masculini vel feminini. Flores masculini pedicellati; pedicelli 1 cm. longi; calyx 2.5 mm. longus, fere ad basim 5-6 partitus; sepala anguste lanceolata, recurvata. Flores feminini sessiles; calyx 2.5 mm. longus, ad mediam 6-partitus, glabra. Fructus infra calycem persistentem pedicellatus, pedicello 3 mm. longo, 3-lobatus, 7 mm. altus, 10 mm. latus, glaber.

Moist region below 1,000 ft.; rather common. Rayigam Korale, Sept. 1856, *Thwaites*! (type); Pasdun Korale, March 1887, *Trimen*! banks of Giniduna near Watagala, S.P., 13.iii.91, *Trimen*! in bog near Ratnapura, 1.iv.27, *Alston*!

10. *Glochidion Moonii* Thw. Enum. p. 286 (1861), C.P. 256, 2150 pp.; Hk. f. in Fl. Brit. Ind. V, p. 325 (1890); Trim. Fl. Ceyl. IV, p. 52 (1898) pp. *Gynoon hirsutum* Wt. Ic. t. 1909 (1852) non *Glochidion hirsutum* Voigt. *Phyllanthus pubescens* Moon. Cat. p. 65 (1824) nomen. *P. Moonii* Muell. Arg. in DC. Prodr. XV, 2, p. 312 (1866). *Diasperus Moonii* O. Ktze. Rev. Gen. p. 601 (1891).

Moist region up to 4,000 ft., common. Adam's Peak, *Gardner*! (type); Palabaddale, Nov. 1853, *Thwaites*! without exact locality, *Walker* (fide Hooker); 3 Korales, *Moon* (fide Moon); Bulutota, 31.iii.27, *Alston*! Dotalugala Kande, 3.v.27, *J. M. Silva*!

Forma *glaucogyna* (Muell. Arg.) *Phyllanthus glaucogynus* Muell. Arg. in Flora XXLVIII, p. 389 (1865); in DC. Prodr. XV, 2, p. 312 (1866). *Glochidion Moonii* Thw. l c., C.P. 2150 pp. (1860). var. *glaucogyna* Hk. f. in Trim. Fl. Ceyl. IV, p. 52 (1898). *Glochidion glaucogynum* Bedd. For. Man. p. 195 (1873?). *Phyllanthus pubescens* var. *glaucogynus* Trim. Syst. Cat. p. 79 (1885) nomen. *Diasperus glaucogynus* O. Ktze. Rev. Gen. p. 599 (1891).

Upper surface of the leaves glabrous.

Ambagamuva *Thwaites*! near Adam's Peak, March 1852, *Thwaites*! Ramboda, *Thwaites*! Deltota, Jan. 1852, *Thwaites*! Sabaragamuva, *Thwaites*! Kandy, 12.vi.26, *Alston*! near Poilakande Estate, Kaduganawa, 4.ii.27, *Alston*!

Var? shrub; leaves bullate, glabrous above, pubescent on veins below; fls. green, without red veins; styles short; whole fem. fl. pubescent.

In the jungle, Madampe, 31.iii.27, *Alston*!

This has the short style of *G. montanum* but the bullate leaves and green perianth of *G. Moonii*.

Trimen (19) has evidently taken his description of the stipules from the Hewesse specimen, which was *Chaetocarpus castanocarpus* Thw. His Var. *subglabra* is here referred to *G. montanum* which it resembles in its shorter style.

The leaves are usually bullate in fresh specimens but this is sometimes lost in drying.

I have taken Gardner's plant as the type, though Thwaites (16) cites C.P. 68 first it does not agree with his description and is here referred to *G. montanum*. There is no specimen of Moon's at Peradeniya, his locality was 3 Korales. Mueller (11) restricted his *P. Moonii* to Gardner's specimen and C.P. 258, referring C.P. 2150 to *P. glaucogynus*. *Gynoon hirsutum* Wt. was also based on Gardner's specimen, and is the first synonym quoted by Thwaites.

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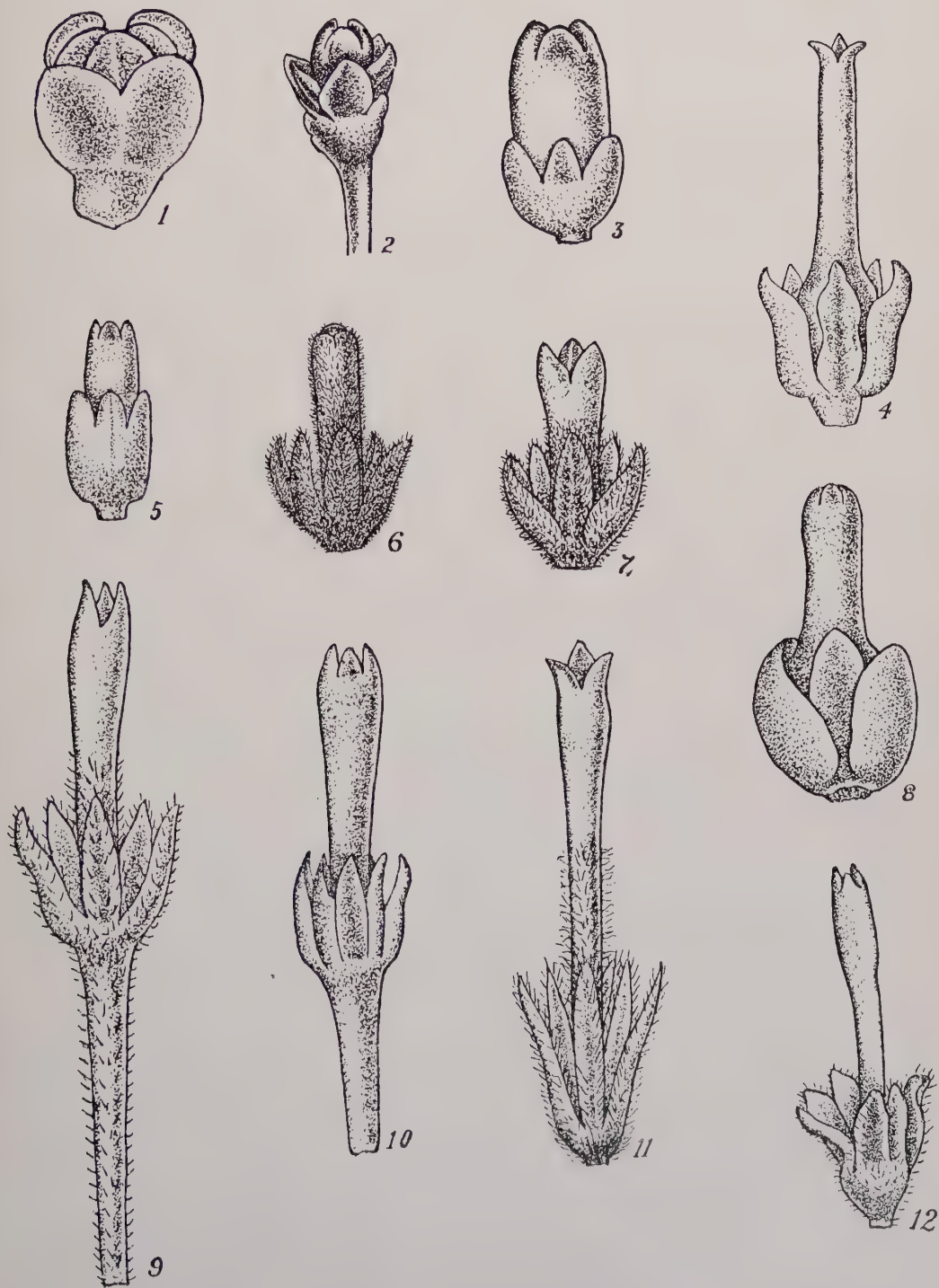
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EXPLANATION OF PLATE I.

Fig.	1	Female flower of <i>Glochidion coriaceum</i> .		
"	2	"	"	<i>G. stellatum</i> .
"	3	"	"	<i>G. pycnocarpum</i> .
"	4	"	"	<i>G. acutifolium</i> .
"	5	"	"	<i>G. pachycarpum</i> .
"	6	"	"	<i>G. montanum</i> (type)
"	7	"	"	<i>G. montanum</i> var. <i>atrichostigma</i> .
"	8	"	"	<i>G. montanum</i> var. <i>glaberrima</i> .
Figs.	9 & 10	"	"	<i>G. nemorale</i> .
Fig.	11	"	"	<i>G. Moonii</i> .
"	12	"	"	<i>G. Gardneri</i> .

(All $\times 7\frac{1}{2}$).

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The Ceylon Species of *Glochidion*.

Notes on *Cryptocoryne*

BY

T. Petch, B.A., B.Sc.

WITH FOUR PLATES

The genus *Cryptocoryne* (*Araceae*) was established by Fischer for the reception of two Indian species, *Cryptocoryne spiralis* and *Cryptocoryne ciliata*, which had been described under *Ambrosinia* by Roxburgh. Additional species were described by Roxburgh, Schott, and other botanists, while in Beccari, Malesia, Engler described eleven new species from Borneo and gave a conspectus of twenty-four known species. In Flora British India, Hooker enumerated sixteen species, and in Flora of Ceylon, five species. The total number of species is now over thirty, confined to the Eastern Tropics.

For our knowledge of the structure of the flower we are indebted almost entirely to Griffith, who recorded the results of his examination of fresh specimens of *Cryptocoryne ciliata* in Trans. Linn. Soc., XX, pp. 263–276. The spadix is small, and it is not easy to determine the details of its structure from dried specimens. Consequently, very little has been added to Griffith's account, and a detailed examination of the living flower is still lacking in the case of the majority of the alleged species.

In Ceylon, *Cryptocoryne* has been considered very rare. *Cryptocoryne Thwaitesii* Schott, hitherto the best-known species, occurs in the wet low-country in the south-west of the Island. *C. Nevillii* Trimen was described from a single collection made by Nevill in the Eastern Province. *C. Beckettii* Thwaites was collected in 1865 in Matale East, and there are two subsequent collections assigned to this species in Herb., Peradeniya. The record of *C. spiralis* Fisch. is based on specimens in Herb. British Museum, said to have been collected by Koenig, who visited Ceylon in 1780 and 1781; while *C. Walkeri* Schott was described from specimens in Herb. Kew, collected in Ceylon by Walker (1830–38).

An investigation of the Ceylon species of *Cryptocoryne* was begun by the late Mr. H. I. van Buuren, his interest having been aroused during an endeavour to determine the identity of the Ceylon medicinal plant

known by the name Ati-udayan. In Ceylon, this name was supposed to indicate *Lagenandra lancifolia* Thw., while in Indian medical books it was said to be applied to both *Lagenandra lancifolia* and a *Cryptocoryne*. As *Lagenandra lancifolia* is a Ceylon endemic, it would appear that the latter statement combines both Indian and Ceylon information.

The name Ati-udayan was recorded by Moon for a Ceylon plant which he referred to *Arum minutum* Willd. Moon's plant has been taken to be *Lagenandra lancifolia* Thwaites, though I am not aware whether his specimen is in existence. Consequently, Ceylon marsh plants for which the name Ati-udayan has been given by the villager, have, if not in flower, been assigned to *Lagenandra lancifolia*. For very many years, it has been customary to maintain, in the collection of marsh and water plants in the Royal Botanic Gardens, Peradeniya, a pot of plants, labelled *Lagenandra lancifolia*, but the plants were not observed to flower under those conditions. On making enquiries, Mr. van Buuren found that they died out periodically, a fresh supply being then obtained from a neighbouring village, and a visit to the stock locality resulted in the discovery of the flowers, which showed that the plant was *Cryptocoryne*. Subsequently, specimens of Ati-udayan were obtained from different localities in Ceylon, and these all proved to be *Cryptocoryne*. In a mss. note,—no doubt the introduction to an intended account of his observations,—Mr. van Buuren wrote:—

“The writer has endeavoured to assemble together from various parts of the Island living plants that are commonly called Atiudayan. In no case has the writer been able to find any attempt at its cultivation, but a villager in the Kandy district can more or less point out a spot where Atiudayan may be found growing. It is customary to encourage any Atiudayan that may come up round and about a spring to grow there, and it is at the head of a spring that irrigates a paddy field that these plants might be found growing. The interesting point is that in all cases investigated up to date the plant commonly known as Ati-udayan is a *Cryptocoryne*.

“*Lagenandra lancifolia* Thwaites on ‘banks of streams and rivers in the moist low-country, common,’ has never been found by the writer. On banks of streams and rivers, plants with leaves and a growth like *Lagenandra lancifolia* have been found very commonly by the writer, but in all cases, on transplanting them into pots with the aquatic plants in the R. B. G., Peradeniya, they have when flowered given the characters of *Cryptocoryne*. The *Cryptocoryne* spp. are not so rare as the notes in Trimen's Flora make them out to be. They flower generally once a year between December and February, and if found not in flower it has been

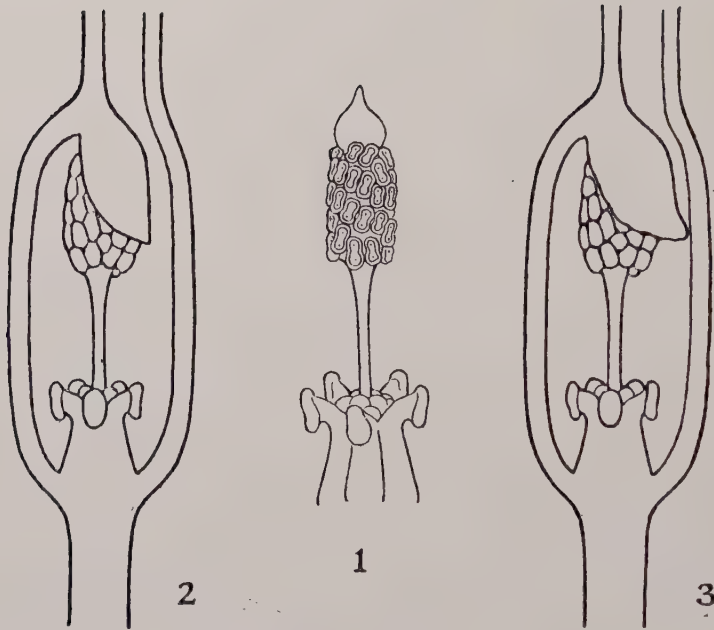
customary to regard them as identical with Thwaites' *L. lancifolia*; hence the record that this latter plant is common, when rather it should be noted as endemic and rare, if not very rare."

Mr. van Buuren's collection included four species at least. One of these, *Cryptocoryne Thwaitesii*, from Hinidun, soon died at Peradeniya, but three other species have survived. The chief object of the present note is to draw attention to certain characters of the spadix which are common to these three species and the available herbarium specimens of the species previously recorded from Ceylon.

The rootstock is crowned by a rosette of leaves and the spathes arise singly in the axils of the leaves. The spathes are pedicellate, but as the rootstock is buried rather deeply in the mud, the bulb and the lower part of the tube are completely hidden. The spathe consists of a basal oblong-oval bulb, 1-1.5 cm. high, which passes somewhat abruptly into a tube, usually many times as long, and the latter terminates obliquely above in a limb of varying length. Occasionally the mouth is merely obliquely infundibuliform; more generally, the lower edge is recurved and the limb almost plane and spirally twisted. But in the same species, the larger examples may have the limb twisted, while in the smaller it is not. Round the mouth of the tube a crescentic area, broadest at the median line of the limb, is demarcated above by a raised line; this collar is usually more deeply coloured than the limb. The bulb is not symmetrical, being more inflated on the side opposite to the limb than the other. The interior of the tube is lined with close-set conical hairs, about 50 μ high, perpendicular to the wall; the wall of the bulb is lacunose on the interior surface.

The basal part of the spadix (Text figure 1) consists of a single whorl of five or six (rarely seven) coherent carpels, the apices of which are free and bend outwards as so many massive styles. These styles are laterally compressed, and are capped by peltate stigmas, directed obliquely downwards. The stigmas are minutely papillose, oval, rounded at the margin, and either plane or very slightly depressed in the centre. In the Ceylon species, the stigma is not infundibuliform, as figured in Engler-Prantl for *C. spiralis*. The carpels are usually white and subtranslucent, but sometimes pale green, sometimes flecked with purple, while the stigmas are sometimes pale purple.

From the centre of the whorl of carpels there arises a very slender white column which expands above into a cylinder on which the sessile anthers are arranged more or less in spirals. Above the anthers the spadix terminates in a globose appendage which is drawn out to a point above and resembles the conventional dome of a mosque.

Bulb and spadix of *Cryptocoryne* $\times 6$

From the junction of the bulb and the tube, an orbicular flap extends downwards into the bulb. This is united to the wall of the spathe by a comparatively narrow base above the more inflated side of the bulb. The spadix is situated beneath this flap, in the more inflated part of the bulb, and its apex is united to the wall of the spathe at the junction of the latter with the flap. Sometimes the apex ultimately separates from the wall. Very frequently the spadix is not vertical, but is pressed by the flap towards the more inflated side of the bulb.

When the spathe first opens (Text figure 2), the flap is closely applied to the spadix and forms a hood which shields the antheriferous part for about one-half or two-thirds of its length. The flap is then white, and its margin is straight and rather thick. When, or just before, the anthers open, the flap becomes more convex above and its margin recurves, and it now extends away from the spadix and closes the entrance to the bulb (Text figure 3). Later, the flap falls back into its original position. When extended across the tube the flap is pale yellow and translucent, and its margin appears thinner than before.

Flies have been observed in the bulb on several occasions. When the spathe opens, there is a clear passage between the flap and the wall

of the bulb, but when the anthers open, the flap extends across and closes the entrance of the bulb. Any flies then in the bulb will remain imprisoned until the flap returns to its first position, and during that period they may come in contact with the pollen, which is extruded from the anthers in a viscous fluid. But there is apparently nothing to prevent the escape of the flies before the anthers are ripe.

A spathe was collected in the evening, one side of the bulb cut open, and the flap observed to be closely applied to the unripe anthers. This flower was then placed on moist filter paper in a Petrie dish, and on the following morning it was found that the flap had extended across the entrance of the bulb and each anther was crowned by a viscid globule containing pollen.

The movement of the flap appears to be brought about by continued growth. It was at first thought that it might be caused by some alteration in size of the peculiar apex of the spadix; but the latter does not appear to alter, and, from its position, it could scarcely produce such an effect.

The angle between the recurved apices of the carpels and the slender column is filled by globose bodies, yellow to orange in colour, and slightly white pruinose when old. These accessory bodies may be equal in number to the carpels and alternate with the latter, or they may be up to twice as numerous. They are sometimes lobed, but usually simple, and are adherent to one another laterally (see later). They form a compact whorl, or a slightly elevated heap, which rarely rises above the level of the apices of the carpels. Because of their colour, they are very conspicuous in fresh specimens, but in dried specimens they are easily overlooked (Text figures 1-3).

Roxburgh, in Coromandel Plants, did not figure these accessory bodies in *Ambrosinia ciliata*. In Flora Indica, he did not mention anything of this nature in *A. ciliata*, *A. spiralis*, and *A. retrospiralis*, but he recorded that *A. unilocularis* had nectaries above the ovaries.

Blume, in Rumphia, did not figure accessory bodies in *Cryptocoryne spiralis*, nor describe them for *C. spiralis*, *C. ciliata*, or *C. ovata*.

Griffith, in Trans. Linn. Soc., XX, did not figure accessory bodies in *C. ciliata*. In Icones Plantarum Asiaticarum, he did not figure them in *C. spiralis* or *C. alata*, but for *C. cordata* Griff. his figure shows an inner whorl of clavate bodies, and in Notulae, p. 138, he stated of that species, "Corpusculae late clavatae, uniseriatae, ovaria supra pedunculi partis nudaе basin ambiunt." Further, with regard to *C. Griffithii* Schott. he wrote (p. 139), "Space round base of the naked attenuated filiform part of the spadix rather flat, occupied by the lobed, yellowish, papillose bodies in number six, alternating with the ovaria."

Wight, in *Icones Plantarum Indiae Orientalis*, did not figure accessory bodies in *C. retrospiralis*, *C. unilocularis*, or *C. ciliata*.

Engler, in *Mon. Phanerog.*, II, described *Cryptocoryne* as having "Inflorescentia feminea saepius pauciflora, floribus monocyclis vel dicyclis, illis cycli superioris abortivis, illis cycli inferioris inter se connatis"; and he stated that *C. cognata* had "ovariis fertilibus 6, cum sterilibus totidem alternantibus."

In *Flora British India*, Hooker, in the generic description of *Cryptocoryne*, gave "female inflorescence a single whorl of connate one-celled many-ovuled ovaries with a few neuters," but he did not record the presence of neuters in any of the sixteen species there described. In the *Flora of Ceylon*, he described *C. Nevillii* as having "ovaries in a whorl of 6 or 7 (?), with large globose stigmas, surrounding an inner whorl of minute imperfect (?) ones, with globose stigmas"; and added the note, "If I am correct in describing the ovaries as in two whorls, the inner of imperfect carpels, the plant is intermediate between *Cryptocoryne* and *Lagenandra*."

Thus it would appear that these accessory bodies have been previously observed by several botanists. But while those who have examined dried specimens have considered them to be abortive carpels, that interpretation has not suggested itself to those who have examined living plants.

These accessory bodies are present in the Ceylon species, *Cryptocoryne Thwaitesii*, *C. Beckettii*, and *C. Nevillii*, as shown by the herbarium specimens, and in all the four species recently collected. They are stalked and somewhat pear-shaped in longitudinal section (Plate II, figure 1.) A vascular strand runs from the central column up the middle of the stalk and terminates about the centre of the head. The head is parenchymatous, and is covered with cylindrical processes, up to 30 μ high and 12 μ diameter, which are outgrowths from the cells of the outer layer. The processes of adjacent heads interlock, and so simulate a continuous tissue (Plate II, fig. 2). Near the periphery of the head occur large cells, up to 50 μ diameter, which contain bundles of crystals. These cells are not peculiar to the accessory bodies; they occur also in the carpels, immediately beneath the epidermis. The loose cells seen in the photographs of the sections are the tips of the processes of adjacent bodies. The processes are not septate, and they do not abstrict cells.

It is possible that the accessory bodies, either by their colour or by the emission of some odour, serve to attract insects to the base of the spathe and consequently to the stigmas.

The anthers are situated on the enlarged upper part of the column. As a rule, they are crowded, and arranged more or less in spirals (Text

figure 1). The condition figured by Engler (Icones ined.) for *Cryptocoryne Thwaitesii*, in which a few anthers (4-6) are scattered along a slender column, is not usual in that species and was evidently abnormal. The anthers are sessile, oblong-oval in plan, with a slight constriction in the middle which makes them somewhat eight-shaped, and their sides slope slightly inwards to the base. The upper surface is bordered by a narrow incurved margin. Before the anther has dehisced, each half bears a minute conical point.

In transverse section (Plate III, figs. 3, 4), it is found that a theca or pollen sac is situated beneath each conical projection, the theca being bilocular, with each loculus more or less circular in section. From the theca, elongated cells extend radially to the exterior on all sides except the upper; the walls of these cells are thickened in radial lines, and hence this tissue corresponds to the fibrous layer of a typical anther. From the upper edge of the anther, a flap of small-celled tissue extends inwards, and forms the incurved margin. Above the theca, a tissue of isodiametric cells extends upwards into the cone. The outer layer of the cone is continuous with the epidermal layer of the upper surface of the anther. Thus, although the appearance of the anther suggests that it consists of two flask-shaped thecae embedded up to the neck in a ground tissue, that is not actually the case. The outer layer of the conical projection is continuous with the epidermal layer of the anther, not with the wall of the theca.

When the anther is mature, the cells which overlie the theca and fill the conical projection break down and the cone becomes hollow. The apex of the conical projection then dehisces and the pollen is extruded, together with a relatively large quantity of a viscous fluid, in a minute globule. Subsequently, the projection collapses.

References to the extrusion of the pollen appear to have been based in all cases on Griffith's observations. His figure (Trans. Linn. Soc., XX, tab. X, fig. 5) shows a very long tendril issuing from the apex of the conical projection, and in the description of that figure he stated "The opening in the apex of the projecting membrane is very distinct, and through it is seen passing a grumous boyau-looking body of great length." The tendril is about sixteen times the length of the conical projection, and no pollen grains are figured in it.

In the text of his paper, however, Griffith wrote, "At a later period, the apex of the cone is open, and through this opening the contents of the thecae *may be squeezed* (italics mine—T. P.), assuming, from the comparatively small diameter of the apex of the cone, a more or less elongated form. In the instance figured, the length to which they attained was immense. The matter squeezed out resembles exactly

the process which originates from most globules of pollen, when acted on by water, and the very great length above noticed arose probably from the coalition of the processes of several granules occasioned by the pressure exerted. The opening in the cone appears to be of secondary importance; it is evident from the direction of the anthers, from the small size of the aperture, and from the relative diameters of the opening and globules of pollen (*i.e.* pollen grains—T. P.) that it is not sufficient to allow of a free exit of the latter. The necessary free exit of the pollen is secured by the separation of the membrane from the inner margins of the thecae, and at the time of fecundation the globules of pollen will be found uncovered.”

Thus, Griffith's figure merely shows what happens when an anther is subjected to pressure on a microscope slide. It does not show what occurs naturally. If a spathe of which the anthers have not dehisced is gathered in the evening, and placed in a moist chamber, it will be found on the following morning, if the spathe has been in the right condition, that each conical projection bears a minute globule. By bringing the spadix in light contact with a glass slip, one or more of these globules may be removed without damaging the conical projections, and on staining them with iodine, it is found that they contain pollen. Before staining, one cannot be certain that pollen grains are present, only a faint outline of them being visible in the viscous matter; after staining, they show up quite clearly.

It is possible that the tendrils artificially produced by Griffith did not contain pollen grains, or more probable that he did not try any stain. The viscous matter is not the result of the bursting of the pollen grains, as he suggested. On the other hand, it is true that after the collapse of the conical projection, pollen is found in the cup formed by the base of the theca.

Griffith found the pollen of *Cryptocoryne alata* Griff. to be spherical. In all the available Ceylon specimens, both those recently collected and the herbarium examples of *C. Beckettii*, *C. Nevillii*, and *C. Thwaitesii*, the pollen grains are oval or bean-shaped, and thick-walled. Hooker's statement that the pollen of *Cryptocoryne* is vermiform (Flora British India) does not apply to the available Ceylon species.

CLASSIFICATION

As already stated, five species of *Cryptocoryne* have been recorded from Ceylon. One of these, *Cryptocoryne Thwaitesii*, is readily distinguished by its rough crenate leaves and long-tailed spathe, and another, *C. spiralis*, by its linear leaves and ridged limb. Recently, five, possibly six, species have been collected. One of these is *Cryptocoryne Thwaitesii*,

but *C. spiralis* has not been found. It is, however, very difficult to decide from the descriptions and the herbarium specimens whether any of the other four are to be assigned to the species previously described from Ceylon.

Engler, in D.C., Mon. Phanerog., adopted, as the primary character or the separation of the species of *Cryptocoryne*, the relative lengths of the tube and the limb, dividing them into species which had a tube more than two or three times longer than the limb, and those which had a tube shorter than the limb; and in this he was followed by Hooker in Flora British India and Flora Ceylon. But it will be evident from figs. 9-11, Plate V, that the relative lengths of the tube and the limb may vary considerably in the one species. Further, in *C. Beckettii*, in which spathes 14 cm. long have the limb shorter than the tube, the smaller spathes have the limb equal to the tube. It may perhaps be true that in species in which the limb is longer than the tube, that relation still holds good in the case of small spathes; but evidence on this point is lacking, and the extent of the variation in other species makes it doubtful.

Further subdivision has been based on the shape of the limb, and whether it is twisted or not. As regards the latter point, it may be stated that the limb is always twisted in bud; and whether, in the case of those species which have the limb equal to or shorter than the tube, it is twisted after the spathe has opened, depends largely on its size. Further, although the limb is thick and fleshy when fresh, it very soon begins to shrivel when the plant is removed from its watery habitat, and it would not be safe to lay much stress on the shape of the limb, e.g., acute or acuminate, triangular or lanceolate, as observed on dried specimens.

In the case of the leaves, the variation is again extraordinary. It is natural that plants grown in shady situations should have larger leaves than those grown in the open, but the change, as in *C. Beckettii*, from leaves 23 cm. long to leaves 6 cms. or less, is greater than would be expected, in view of the fact that in both cases the plants are partly submerged. Moreover, in this species, the change in size is accompanied by a change in shape. The larger leaves have the base rounded or cuneate, but in the smaller it is distinctly cordate (Plate IV, figs. 2, 3).

Some species are described as having the spathe long-pedicelled, others the spathe sessile. But in the same species the pedicel may vary from 5 mm. to 4 cm. in length. It does not appear probable that sessile spathes can occur in *Cryptocoryne*.

From the descriptions, one would deduce that the presence or absence of the accessory bodies could be taken as the primary distinguishing character. The evidence of the Ceylon plants, however, suggests that

these are present in all species, but have been overlooked. There is very little difference between the spadices of the Ceylon species. The styles are slightly longer in some species than in others, and bend outwards at slightly different angles, but the differences are inappreciable. No available Ceylon species has globose stigmas.

In three of the recently collected Ceylon species, in which the spathes are similar in structure, the leaves vary to such an extent that practically the only tangible character by which they can be distinguished in all their forms is the colour of the limb and the collar.

The following descriptions have been drawn up from fresh specimens. The determinations, however, must be regarded as tentative, until more is known about the species of *Cryptocoryne* described from other countries.

Cryptocoryne Beckettii Thw. Rootstock stout. Leaves up to 23 cm. long, long-petioled, petiole up to 15 cm. long; lamina up to 8 cm. long, 3 cm. broad, oblong-oval or oblong-lanceolate, apex subacute or obtuse, margin crisped in the lower half, base slightly auriculate, not cordate, often oblique; lateral veins 5 or 6, the 2 or 3 lowest from the same point; upper surface dull pale green; cross veins not prominent. Spathe up to 14 cm. long, with a pedicel up to 4 cm. long, bulb 1.75 cm., tube 4.5 cm., limb 4 cm. Limb ovate-lanceolate, slightly twisted, one or both edges more or less denticulate, opening widely and funnel-shaped below with a recurved edge, margin recurved, surface even or faintly rugose. Limb olive yellow; collar reddish purple or chocolate-brown; tube tinged reddish purple above. Carpels 5 or 6; styles short, bending outwards at an angle of about 60° from the vertical; stigmas capitate, oval, slightly convex; accessory bodies present.

Gangaruwa (van Buuren); Kadugannawa (van Buuren); Gangaruwa, January, 1925; Halloluwa, February, 1925. Plate IV, figs. 1-4.

When cultivated in an open situation, the leaves become much smaller, though still long-petioled, and the shape is decidedly different. They are then more ovate, and cordate with a wide sinus at the base. The lamina is about 3 cm. long and 1.5 cm. broad, and the petiole about 4.5 cm. long. Leaves of the same shape occur on young rootstocks among the larger plants in nature. The spathe becomes much shorter, about 6 cm. high, with a pedicel, 6-8 mm. long, bulb 1-1.4 cm. long, tube 2.5-4.5 cm., limb 1.5-2.5 cm.

In all cases, the petiole is long in comparison with the lamina, and the limb is shorter than the tube and only slightly twisted.

The edge of the limb is denticulate, usually on one margin, sometimes on both margins, for varying distances. The limb is stout, and its margin more or less quadrangular in section, and the minute teeth are

situated on the inner edge of the margin. This is the case in all the present species in which the margin of the limb is denticulate, and apparently the same structure occurs in *Cryptocoryne spiralis*, as figured in Bot. Mag. No. 2220.

The leaves bear very minute, lanceolate, adpressed hairs, up to 0.4 mm. long and 50 μ diameter, scattered over both surfaces. These are scarcely visible on the fresh plant, but they show up strongly on leaves preserved in alcohol, owing to the fact that they contain bundles of crystals which appear white on the subtranslucent preserved material. Similar hairs occur on the other species described in this paper.

This species is probably identical with *Cryptocoryne Beckettii* Trimen. The type specimen of the latter, from Matale East, February, 1865, has leaves with an oval-lanceolate blade, up to 8.5 cm. long, 2.8 cm. broad, cordate at the base with a wide sinus, thin, margin crisped, lateral veins 3-5, the two or three lowest from one point, and a petiole up to 9.5 cm. long. These leaves resemble the small leaves of the recent plant in shape, but are larger. Only a bud and the bases of one or two spathes are available, and there is no record of the colour. The broken spathes show a pedicel about 1 cm. long. The bud is about 2 cm. long, without any definite constriction between the bulb and the tube. Trimen stated that the limb was small and caudate, but it is not unfolded, and it is not possible to say what the shape would be when expanded. Accessory bodies are present. The column between the carpels and the anthers is short, but this is probably because the spathe is immature. The broken spathes indicate that when mature they are much larger. The pollen grains are small, 26-32 x 17-18 μ , like those of the recent specimens described above.

A second sheet in Herb. Peradeniya sub *C. Beckettii* is marked Kahata-ata-hela, in chinks of dry rocks, January, 1888. This was apparently collected without flowers, and was assigned to *C. Beckettii* with a query. The lamina is up to 5.5 cm. long, with a petiole 9 cm. long. The lamina is oblong-lanceolate, sometimes, but not invariably, more attenuated towards the apex than in the type, apex usually acute, base cordate with a wide sinus or oblique and not cordate, margin crisped, cross veins prominent. This resembles *C. Walkeri*, rather than *C. Beckettii*.

A third sheet in Herb. Peradeniya sub *C. Beckettii* is labelled Kailla, June 1st, 1866 (? Kella, Ratnapura district). The leaves of this have a lamina up to 10 cm. long and 2 cm. wide, with a petiole up to 20 cm. long. The lamina is narrow-lanceolate, margin not crisped, and the veins are less spreading than in the two previous specimens; in these respects the specimen resembles the Yatielagala plant described

below. The spathe has a pedicel 5 cm. long, a bulb 1.2 cm. long, a tube 5 cm. long and a limb 2 cm. long. A purple colour persists on the collar, and on the upper part of the tube, but the limb is now pale. No tubercles are evident on the limb. The specimen is, however, nearer to the Yatielagala plant than to the type of *C. Beckettii*.

It would appear probable that the second specimen is to be assigned to *C. Walkeri*, and the third to *C. Nevillii*. Trimen's description in *Journal of Botany*, XXIII (1885) p. 269, refers to the first specimen only; that in the *Flora of Ceylon* apparently covers all three.

Cryptocoryne Walkeri Schott. Rootstock stout. Leaves usually long-petioled, up to 21 cm. long; petiole up to 13 cm., lamina up to 8 cm. long, 2.5 cm. broad; varying to a length of 6 cm., petiole 2.5 cm., lamina 3.5 cm., ovate-lanceolate or oblong-lanceolate, often inequilateral, apex obtuse or subacute, margin crisped, baseslightly cordate with a wide sinus, or attenuated abruptly into the stalk, equal or unequal, slightly auriculate, 5 veined, the three lowest from one point, the uppermost three veins and the cross veins prominent, green, purple beneath with purple red veins, and a purple red petiole; spathe up to 8.5 cm. long, pedicel 1.5 cm., bulb 1.2 cm., tube 3.5 cm., limb 3 cm., long; limb lanceolate, acute, up to 8 mm. broad, surface faintly rugose, slightly twisted, lower edge recurved, greenish yellow to bright green, fuscous on the outer surface; collar of the same colour as the limb; tube expanding slightly upwards, grooved down the front, white, strongly sprinkled purple red; carpels 5 to 7, styles short, stigmas subvertical, capitate, flat; accessory bodies present. Fruit globose, 9 mm. diameter, furrowed, crowned with the remains of the styles: ripe seeds not seen.

Gangaruwa (van Buuren); Halloluwa, February, 1925. Plate IV, figs. 5-8.

This species has leaves which resemble those of *C. Beckettii*, but they are more attenuated towards the apex, and are distinguished in the field by the strong *cross* veins. The larger leaves are long-petioled, but the smaller may have the petiole shorter than the lamina. The spathe differs in colour from that of *C. Beckettii*, but is similar to the latter in structure.

Cryptocoryne sp. indet. Rootstock stout: leaves up to 8 cm. long, petiole as long as the lamina; lamina up to 4 cm. long, 2 cm. broad, oblong-oval, apex obtuse or subacute, base cordate, auricled, the auricles close to the petiole, dark green, glossy, lateral veins 5 or 6, the three or four lowest from one point. Spathe up to 9 cm. long; pedicel 0.5 cm., bulb 1-3 cm., tube 2-3.5 cm., limb 2.5-3.5 cm.; limb long-triangular, apex acute, slightly twisted, appearing smooth but minutely rugose or lacunose, margin dentate, dark olive green or blackish green, sometimes

paler at the margin; collar dark purple; spathe sometimes opening widely with a recurved margin round the mouth, sometimes with a narrow vertical opening; tube with a well-marked groove down the front, white, mottled purple, expanding slightly above; carpels 5-7, styles curved outwards, short, stigmas capitate, oval; accessory bodies as numerous or twice as numerous as the carpels.

Ratnapura (van Buuren). Plate V, figs. 1-5.

This species differs from *C. Beckettii* and *C. Walkeri* in its comparatively short-petioled, dark green leaves, and especially in the base of the leaf. These characters appear to be constant under cultivation. The spathe is similar in structure to those of *C. Beckettii* and *C. Walkeri*, but differs in the colour of the limb.

It has not been found possible to match this with any specimen at Kew or the British Museum. *Cryptocoryne cordata* Griff., from the description and Engler's figure, has broader leaves, a very long tube, and a comparatively short limb. It differs also in colour, the limb being *atropurpurascens* and the collar *lutescens*. The stigmas figured by Engler are unlike anything observed in Ceylon specimens of *Cryptocoryne*. *Cryptocoryne auriculata* Engler, from his figure, has somewhat similar leaves, though not oblong, but the limb is more than twice the combined length of the tube and bulb.

Cryptocoryne Thwaitesii Schott. The limb of this species is lanceolate, with an elongated, linear tip, and about three times as long as the bulb and tube together. In recent examples the elongated tip is solid. The styles are directed upwards at an angle of about 45° and are about 0.5 mm. long, approximately about half the length shown in Engler's figure. The stigma is capitate, oval, flat, and broader vertically than the style, which expands at the apex to form a buttress. Accessory bodies are present. The anthers are crowded together in a cylindrical column as in text fig. 1; the condition figured by Engler, 4-6 anthers on a slender column, was probably abnormal.

Cryptocoryne Nevillii Trim. Rootstock slender, elongated, with stout white lateral stolons. Leaves long-petioled, petiole up to 14 cm. long, with a lamina 7 cm. long and 2 cm. broad, varying in exposed situations to a total length of 4 cms., with a lamina 2 cm. long and 5 mm. broad; the larger leaves long-triangular, or narrow lanceolate, base cuneate, or almost deltoid, the smaller narrow lanceolate or lozenge-shaped, apex obtuse or subacute, base of the larger leaves slightly auriculate; lateral veins 3 or 4, the lowest 2 or 3 from the base, at a small angle with the midrib and sub-parallel; cross veins not prominent. Spathe up to 6 cm. high; pedicel up to 1 cm., bulb 1 cm., tube 2 cm., limb 2 cm.; limb lanceolate to triangular, acute, usually opening widely, face papillose with

scattered conical papillae when fresh, not evident on dried specimens. Limb and collar deep red purple, tube sprinkled with red purple, or deeply coloured red purple in the smaller examples. Tube with a well-marked groove extending from the lowest point of the mouth to just above the bulb, where it curves shortly to one side. Carpels 5 to 6, usually 6; styles short, almost horizontal; stigmas capitate, oval, slightly convex; accessory bodies present. Fruit urceolate, 7 mm. diameter, on pedicels up to 3 cm. long. Seeds wedge-shaped, five-angled, the upper surface oblique and convex, the two inner faces slightly concave, the lower end conical, angles not warted.

Yatiellagala (van Buuren); Halloluwa, Feb., 1925. Plate V, figs. 6-12.

The variation in the spathe of this species is illustrated in figs. 9-11, Plate V. These are all from plants with small or medium leaves, figs. 9 and 10 from plants grown in the Botanic Gardens, and the smallest from a plant growing wild in an open situation. In the latter instance some of the spathes did not exceed 2 cm. in height. It is probable that the actual range of variation will be greater than is shown by these figures: the long-leaved plants have not been collected in flower, and it is to be expected that they will have longer spathes.

It may be noted that in the same locality as the above plant, there occurs a form with similar long triangular leaves, but cordate at the base and with prominent cross veins. This is probably another species, but it has not yet been collected in flower.

It would appear possible that this is *Cryptocoryne Nevillii*. The type of the latter has similar stout stolons which were described in the Flora of Ceylon as fleshy root fibres. The leaves are up to 14 cm. long, with a lamina up to 6.5 cm. long and 1.5 cm. broad. The breadth of the lamina varies from 0.7-1.5 cm., and it is narrow oblong-oval or narrow lanceolate, cuneate at the base or attenuated into the petiole. One leaf is narrow obovate-oblong, rounded at the apex. The description of the leaves as, *inter alia*, linear appears to have been based on a spathe. The spathe is up to 15.5 cm. long, with a pedicel up to 2 cm., bulb 1 cm. (prox.), tube 11 cm., and limb 3 cm. The limb is narrow lanceolate, 3-4 mm. wide; in four flowers it may have been purple, but the fifth is pale. The tube is marked with rather large purple spots at the mouth. The specimen examined had 5 carpels, with short styles, and capitate stigmas directed slightly obliquely downwards. The stigmas are not globose. Accessory bodies are present, as noted by Hooker. The pollen grains are large, 40-50 x 29-40 μ , as in the species from Yatiellagala. No papillae could be detected on the limb.

According to Nevill, who collected the type of *C. Nevillii*, the tube was spotted with dark purple, and the limb greenish purple. No mention

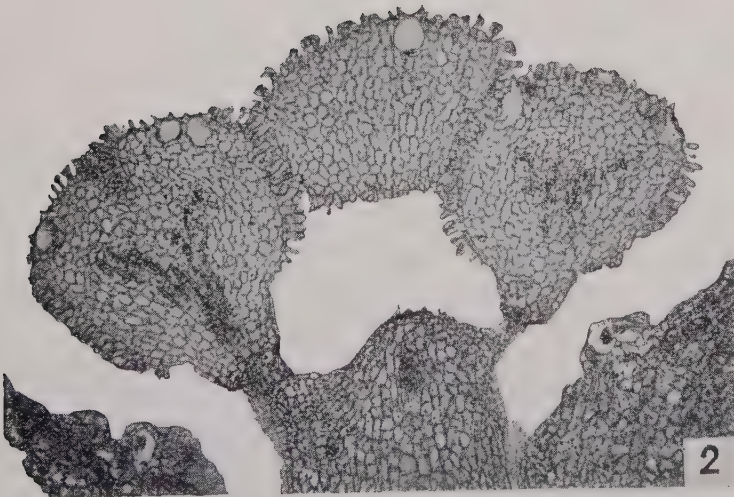
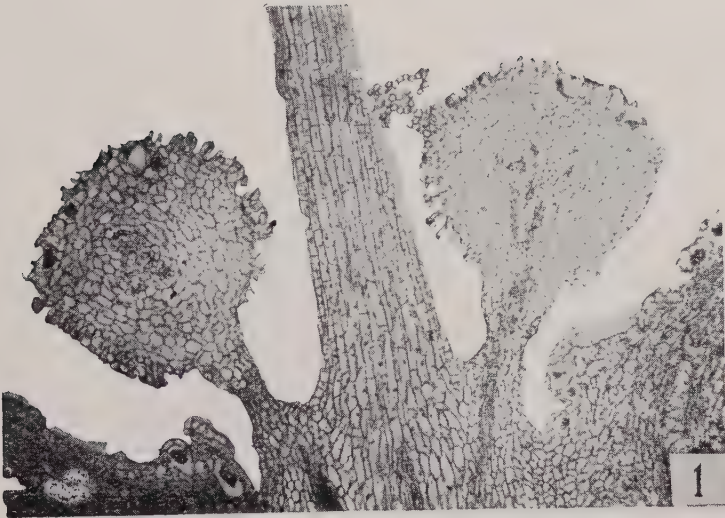
was made of a coloured collar, and this area in the type specimens is occupied by discrete spots. These may be variations in the larger examples, but until the type has been matched by fresh specimens it is not certain that the recent Yatiellagala plant is *C. Nevillii*. Attempts to obtain specimens of Atiudayan from the type locality of *C. Nevillii* have not been successful.

The statement in the Flora of Ceylon that in *C. Nevillii* the limb is longer than the tube is probably a slip of the pen. On the other hand, if the Yatiellagala specimens are the same, there is another possible explanation. As already stated, there is a well-marked groove down the front of the spathe in the Yatiellagala flowers, and in section the tube resembles a sheet curved round and united into a tube by its edges, the edges being rounded and the junction very narrow. Further, in some specimens the fusion is incomplete here and there along the groove. Consequently it is possible that, in the examination of herbarium specimens, the two sides might be separated and thus the limb would appear to be longer than it really is. In the measurements given in this paper, the length of the limb is measured from the tip down to the collar.

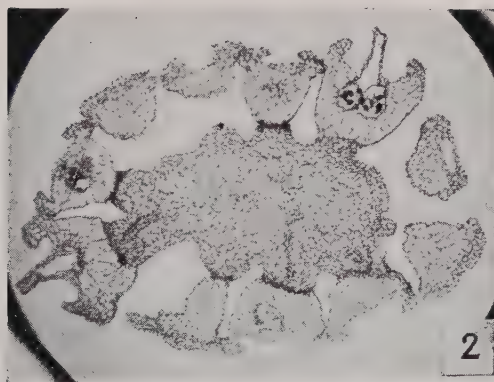
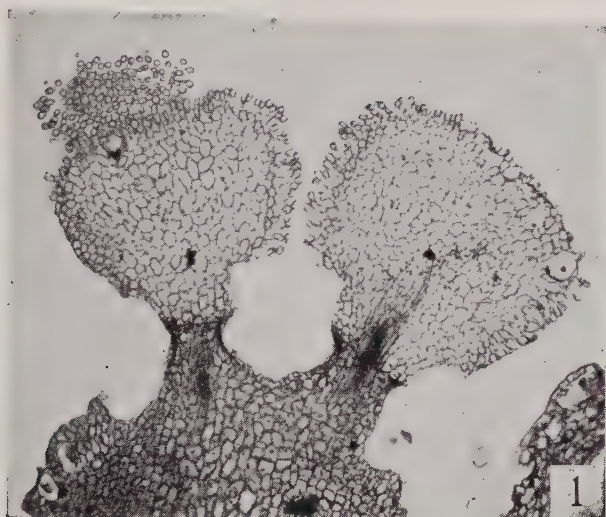
EXPLANATION OF PLATES

- Plate II*, Fig. 1. Longitudinal section of the column and two accessory bodies, $\times 66$. Parts of the styles are seen on either side at the base.
- Fig. 2. Longitudinal section of three contiguous accessory bodies, showing the interlocking of the peripheral processes, $\times 66$.
- Plate III*, Fig. 1. Longitudinal section of two accessory bodies, $\times 66$.
- Fig. 2. Cross section of the anther column, $\times 40$.
- Figs. 3, 4. Transverse section of an anther, passing through the conical process, $\times 66$.
- Plate IV*, Fig. 1. *Cryptocoryne Beckettii*, leaf viewed laterally, the greater part of the petiole omitted, natural size.
- Fig. 2. Ditto, leaf from upper side, natural size.
- Fig. 3. Ditto, an entire leaf from a cultivated plant, nat. size.
- Fig. 4. Ditto, a small spathe, natural size; the groove in the upper part of the limb is accidental.
- Fig. 5. *Cryptocoryne Walkeri*, leaf, natural size.
- Fig. 6. Ditto, venation of leaf, as seen from the back, natural size.
- Figs. 7, 8. Ditto, spathes, natural size.

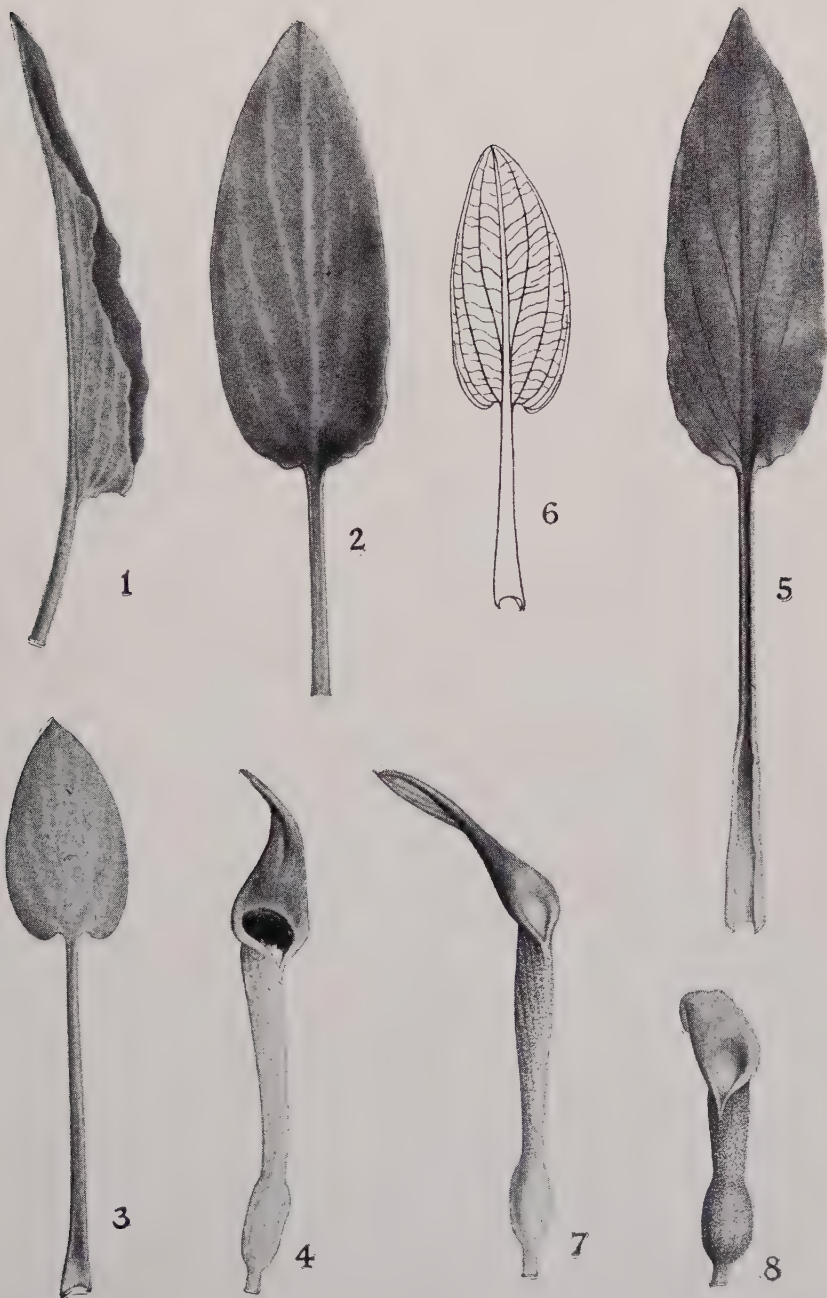
- Plate V,
- Fig. 1. *Cryptocoryne* sp. indet, leaf, natural size.
Fig. 2. Ditto, leaf viewed laterally, natural size.
Fig. 3. Ditto. venation, as seen from the back, natural size.
Fig. 4. Ditto, spathe, natural size.
Fig. 5. Ditto, upper part of spathe, natural size.
Figs. 6, 7. *Cryptocoryne Nevillii*, leaves from a cultivated plant, natural size.
Fig. 8. Ditto, venation, as seen from the back of the leaf, natural size.
Figs. 9-11 Ditto, spathes, natural size.
Fig. 12. Leaf of the probable wild form of the Yatiellagala plant, natural size.



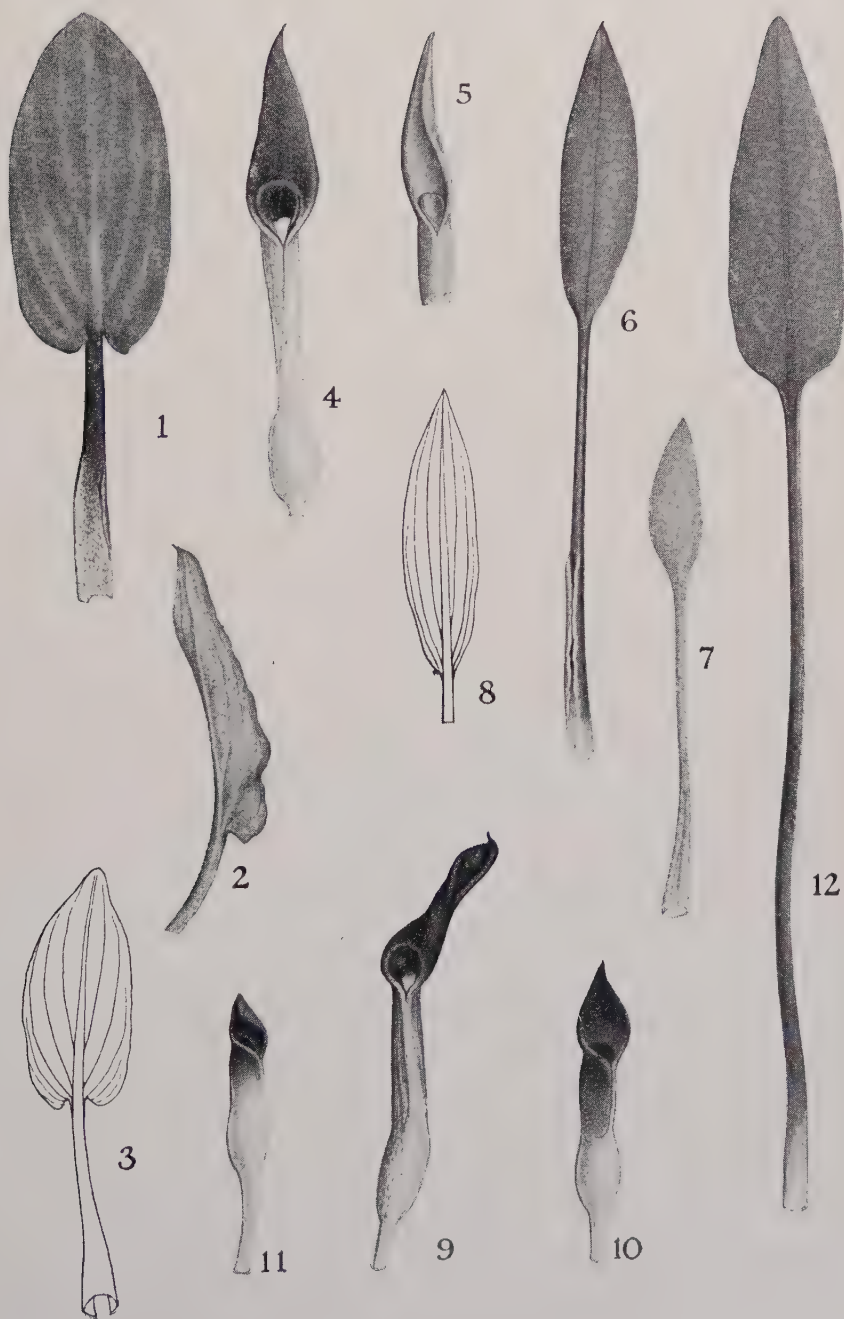
Cryptocorne.



Cryptocoryne.



Cryptocoryne.



Cryptocoryne.

**Corticium vagum B. & C.—The cause of a disease of
Vigna oligosperma and other plants in Ceylon**

BY

C. H. Gadd, D. Sc.

Mycologist, Tea Research Institute, Ceylon

AND

L. S. Bertus

Assistant in Mycology, Department of Agriculture, Ceylon

WITH FOUR PLATES

Corticium vagum B. and C. (= *Rhizoctonia solani* Kühn) was first recorded in Ceylon by Petch⁽¹⁾ (10). The fungus was collected on the stems of *Solanum tuberosum* L. at Diyanilla in 1918 (No. 5675 Herb. Perad.). Petch's notes on this specimen state "Base of stems covered with fine white film, easily separable, powdered, broken into very minute tufts. Hyphae stout, 8 μ diam., basidia clavate or oval, 16 $\times$ 10 μ , 4 spored, clustered, sterigmata conical 2-4 μ long: spores globose, hyaline, smooth 8-9 μ ." Burt, to whom specimens were sent, stated in a letter dated April 16th, 1919: "Your 5675, *Corticium vagum* B. and C. does not afford spores but has the characteristic aspect and hyphae of the species as it occurs in this country. Sometimes the fructification is loosely attached to the potato stem but not always."

In 1919, the mycelial stage (*Rhizoctonia solani*) of the same fungus was recorded on *Dolichos Hosei*, at the Experiment Station at Peradeniya. It was not until this plant, now known as *Vigna oligosperma*, was grown on an extensive scale as a cover crop and green manure that the fungus became of economic importance in Ceylon. In view of the particularly bad record of this fungus in the many countries in which it is known, its frequent occurrence in association with a disease of *Vigna* in Ceylon necessitated a fuller enquiry into its capacity to become a serious pest.

(1.) In Ann., R.B.G., Perad., VII p. 288 the name *Corticium vagans* B. & C. is given in error for *Corticium vagum* B. & C.

During the course of these investigations the mycelium of the fungus has been found on groundnuts (*Arachis hypogaea* L.), and also on paddy (*Oryza sativa* L.), plantain (*Musa paradisiaca* L.) and *Acacia decurrens* Willd., and the *Corticium* stage has been found on groundnut.

SYMPTOMS

On *Vigna oligosperma*.

The disease on *Vigna* usually occurs in patches of greater or smaller area. Attention is usually drawn to these patches during wet periods when the growth on these areas is less dense than the surrounding cover. On examination it is found that the lower leaves are rotting; the diseased leaves though still retaining their normal shape are slimy and stuck together so that it is difficult to separate them without tearing. Diseased leaves may also be found attached to apparently healthy ones. As the weather becomes drier, the diseased leaves shrivel up, turn grey and form a layer on the soil or remain stuck to healthy leaves. Plate VI gives a general idea of the appearance of plants on the diseased areas; it shows healthy leaves to which withered leaves are attached as well as the kind of mat formed by the rotted tissues. So long as the weather remains dry, the *Vigna* grows well and gradually forms a good cover over the diseased areas, but, with the advent of rain, the disease again kills off the leaves and enlarges the attacked area.

Growing over the diseased leaves and matting them together may be seen the fine hyphae of the fungus. When a diseased leaf comes in contact with a healthy one the hyphae grow over the healthy leaf, so that the two become stuck together. The healthy leaf then becomes infected and the disease is spread.

Loosely attached to diseased leaves and infected stems may frequently be found small brown seed-like bodies or sclerotia, which are flattened on one side and measure up to 4 mm. in length. They are so loosely attached that they readily fall to the ground if the diseased plants are roughly disturbed.

The disease becomes prominent mainly in wet weather; moist conditions being necessary for a vigorous growth of the fungus. There is, therefore, a continuous struggle between the *Vigna* and the fungus; during wet periods the fungus gets the upper hand and the *Vigna* dies back; when the conditions become drier and less favourable for the fungus the *Vigna* recovers and makes good growth. Very rarely is the *Vigna* killed outright in Ceylon, but the soil becomes badly infected with sclerotia and diseased leaves,

On groundnut (*Arachis hypogaea*).

A similar disease occurred on groundnuts at the Farm School, Peradeniya, in October, 1925. The diseased plants were brown and withered and bore numerous brown sclerotia similar to those found on *Vigna*. The disease started at ground level but later spread to all parts of the plant and to other plants in contact with infected tissues. On gently shifting aside the green growth on the plot, a mass of dead and dying material was found beneath; and on these tissues the typical sclerotia were found in abundance. Fine wefts of hyphae attached dead leaves loosely together in a similar manner to that noted on *Vigna*.

A close examination revealed the presence of a white or greyish, powdery layer on the lower surfaces of green and apparently healthy leaves of some of the plants (Fig. 2, pl. VIII). A similar grey coating was also found on some of the creeping stems not exposed to sunlight. This grey coating extended for several inches along the stems and completely encircled them; in other cases it developed on the lower, unexposed surface only. The white or greyish coating, on microscopic examination, proved to be the fructification of *Corticium vagum*, which has been shown by Rolf and others to be the perfect stage of *Rhizoctonia solani*. The leaves bearing these fructifications exhibited no signs of injury, whereas attacked leaves not bearing fructifications were withered and brown. Petch (11) has pointed out that, as a general rule, the leaves which bear basidia of repent *Corticiums* abundantly are not injured by the fungus. *Corticium vagum* on *Arachis* conforms with this rule.

In the same plot, and frequently on the plants bearing the brown sclerotia of *R. solani*, were found other but smaller sclerotia measuring 0.3–0.7 mm. in diameter. They were first white but finally became brown, globose, glabrous and shining. It was later demonstrated that these sclerotia had no connection with those of *R. solani*, nor with the basidiomycete fructification, so further reference will not be made to them here.

On paddy (*Oryza sativa*).

In November, 1925, diseased paddy plants were received from the Experiment Station, Anuradhapura, on which were present fungus hyphae and sclerotia similar to those found on *Vigna* and *Arachis* (Pl. VIII, fig. 1). The plots on which the disease occurred had recently been levelled. In the levelling operations two or three feet of soil had been cut from the higher end and drawn over to the lower end; this resulted in a difference of soil fertility at the ends of the plot. The plants on what had been the lower end had grown more vigorously than those at the other end,

and it was amongst the more vigorous plants that the disease occurred first. When the plots were examined in December, there were two or three inches of water on the field and the paddy was two months old from sowing.

An examination of the diseased plants in the field showed the presence of a brown discoloration at the base of the culm at about water level. In some cases the lesion was higher up the stem and well above the actual water level of the field. Sclerotia of *R. solani* were found on the surface and between the leaf sheaths. On pulling the plants from the mud the greater part of the aerial portion of badly diseased plants separated from the roots owing to a rot of the leaf bases, and an offensive odour was emitted. Diseased specimens which bore no sclerotia when collected in the field, produced them in abundance after being placed in a beaker of water for a few days.

The fungus was not found in the immediate vicinity of the plots and there was no direct evidence as to the source of infection. The bunds were clean and free from weeds.

On plantain (*Musa paradisiaca*).

In January, 1926, a disease of ash plantains (a cooking variety), which was characterised by the yellowing of the leaves when the plants are about to bear fruit, was reported from the Kurunegala district. The leaves turned yellow and wilted in succession from the oldest to the youngest; the yellowing and drying proceeded from the margin to the midrib. The young fruits turned black and failed to ripen.

An examination of the plants showed that, in some cases, a soft rot was progressing downwards from the young bunch of fruit along the main axis towards the youngest leaves. This symptom must, however, be regarded as of secondary importance as the general effect of the disease on the plant was that of shortage of water, and because the rot of the fruit stalk always started after the yellowing of the leaves. The main stem and the rhizome remained white and healthy, but many of the roots were found to be dead; the cortical tissues of others were blackened in large or small patches. On the surface of the diseased roots was found the mycelium of a species of *Rhizoctonia* which, later, after growing in pure culture proved to be *R. solani*. No sclerotia were found on the plants but these were produced in culture.

The disease resembles in many respects that recorded by Nowell (8) in Grenada and termed Eelworm Black Rot. Eelworms were found in the roots of Ceylon specimens but not in great abundance, but there was no peripheral blackening of the rootstock. The fungus was readily isolated from diseased roots in which no eelworms could be found.

Although it is possible that the disease in Ceylon may be caused by eelworms, it appears more probable that the fungus is more intimately concerned.

It would appear that the fungus is not very virulent on plantain roots, as young plants do not show any visible sign of attack. It is probable that the plant is able to replace roots faster than they are lost by the disease, until the plant commences to form fruits. Then, all the available food supply is required for the formation of fruits, with the result that new roots are not formed sufficiently rapidly to keep pace with the progress of the disease. For this reason the plant suffers from a water shortage, the leaves wilt and become yellow, and the young fruits become attacked by *Gloeosporium musarum* and other fungi.

On *Acacia decurrens*.

Complaints had been received from the Forestry Department that young *Acacia* plants in the Kurunegala district were being killed by termites. The plants were ringed at ground level which resulted in their deaths, but the termites concerned were the common scavenging termites which rarely attack healthy vegetable tissue. It appeared probable, therefore, that the attack by termites was secondary and that these insects removed the cortical tissues of the *Acacias* after they had been killed by some other agency. The activities of the termites, however, removed all traces of the primary organism. In February, 1926, a specimen was received from which the cortical tissue at ground level had been partly removed by termites, and which bore a copious mycelium of *R. solani* at the attacked region. No sclerotia were found on the specimen, but when the fungus was grown in culture, sclerotia with the characteristics of this species were produced. It appeared very probable that this fungus was the original cause of the trouble and the termite attack started after the cortical tissues were killed.

MORPHOLOGY

Mycelium.

The morphological characteristics of the hyphae from the different hosts are very similar. The superficial hyphae are colourless when young, and abundantly branched. The branches arise almost at right angles to the parent hyphae, but somewhat inclined towards the same direction of growth (Pl. IX, fig. 13). After growing but a short distance the branches change their direction of growth, which frequently results in the branch lying parallel with the parent hypha. The base of the branch is usually constricted and the first septum is formed 5–15 μ from this point. The hyphae vary in diameter from 7 to 10 μ , the individual

cells being 50-175 μ long. Sometimes fusion occurs between hyphae. Rarely, the lateral walls of two hyphae lying side by side may fuse where they come in contact; more frequently the apex of a branch fuses with the lateral wall of another hypha with which it has come in contact, resulting in anastomoses as shown in figs. 11 and 12 of plate IX. As the hyphae become mature they turn yellowish brown, sometimes brown, in colour.

The hyphae inside the diseased tissue are abundant, irregularly swollen, much branched and up to 10 μ in diameter (Pl. IX, fig. 14).

Sclerotia.

The sclerotia on *Figna*, paddy and groundnut become visible as fluffy aggregations of hyphae. They are white at first, but the colour soon changes to brown or purple-brown. They are hard and compact, globose or pulvinate, more or less flattened, particularly on the side attached to the plant, and measure up to 4 mm. in diameter. Usually they occur singly but when produced abundantly, two or more may fuse into a mass. The surface is smooth but irregularly pitted and often covered with a surface layer of matted hyphae. In section there is no differentiation into cortex and medulla, the structure being homogenous, consisting of swollen irregular cells of fairly uniform size. A section through a sclerotium is illustrated in plate VIII, fig. 7.

Fructification.

The fructification found on *Arachis hypogaea* consisted of a powdery white or greyish coating on the under surface of the leaves and on the creeping stems. This covering when examined under a lens has the appearance of a loose, narrow-meshed net-work of loose hyphae.

In surface section, a loose net-work of branched vegetative (*Rhizoctonia*) hyphae 8-10 μ in diameter is readily distinguished. Overlying these hyphae are masses of small rounded cells which bear some resemblance to conidia. The origin of these cells is not at first apparent, but in suitable sections it may be ascertained that the ordinary *Rhizoctonia* hyphae give rise to short septate branches. The cells of these branches rarely exceed 16 μ in length and are frequently rounded. These short celled hyphae branch frequently, and terminate in club-shaped cells bearing two or more, usually four, sterigmata at the apex (Pl. IX, figs. 1 and 2). The powdery appearance of the fructification is due more to the nature of the hymenial hyphae than to the presence of spores or basidia. The sterigmata are 5-10 μ long and the spores produced on them are hyaline, oval, with an apiculum at the base, and measure 7-12 $\times$ 4-6 μ with a mean of 8.8 $\times$ 5.2 μ from 50 measurements,

Small powdery patches have also been found on the under surface of *Vigna oligosperma* leaves. These patches have the same structure as those described on *Arachis*, but very few basidia or spores were found. The close agreement in structure leaves little doubt that the patches on *Vigna* are immature fructifications of the same *Corticium* as occurs on *Arachis*, viz., *C. vagum*.

Germination of Spores.

Spores germinate after 24 hours in distilled water or in ordinary tap water. The germination capacity in this medium is rather poor, less than 50 per cent. of the spores germinating. The germination capacity is better and the germ tube is produced earlier when a small amount of maize meal agar is dissolved in the water. The spores usually germinate by putting out a single germ tube at the end opposite to the apiculum (Pl. IX, fig. 4). The germ tube after 48 hours is of considerable length, hyaline, septate, frequently with constrictions at the septa, and measures 3–6 μ in diameter. In some cases a branch is formed from the basal cell of the germ tube, close to the spore (Pl. IX, fig. 5). Some spores produce two germ tubes, one at each end (Pl. IX, fig. 7); rarely a tube may arise from the side of the spore as shown in fig. 6.

Shaw (15) was unable to get the perfect stage of *Corticium vagum* into culture on artificial media and concluded that this stage is strictly parasitic. No difficulty was experienced in this respect in Ceylon. Single spore cultures were easily obtained and the fungus grew readily on maize meal agar. Sclerotia were obtained in culture on artificial media, and when the fungus was inoculated on *Arachis*, characteristic symptoms of the disease and sclerotia were produced.

CULTURES

Isolations.

Pure cultures were readily obtained from sclerotia by first washing them in 0.1 per cent. corrosive sublimate solution and then in sterile water before placing them on the culture media. Fragments of tissue from the interior of sclerotia also gave rise to pure cultures. Separate cultures were obtained from sclerotia collected from *Vigna*, *Arachis*, and *Oryza* and grown on maize meal agar and Bovril agar. The strains from plantain and *Acacia* were readily obtained from the surface mycelium. The hyphae grew rapidly in culture and by subculturing from the advancing edge of the mycelium it was possible to eliminate bacterial and other contaminations.

In addition, cultures were made from the spores obtained from the fructification on the leaves of *Arachis*. These were obtained by placing

small pieces of leaf bearing the fructification on a sterile cover glass in a sterile petri dish containing a little water. In twenty-four hours the spores became visible on the cover glass which was then transferred to a tube containing maize meal agar, after removing the leaf. The cover glass was placed on the medium so that the side bearing the spores came in contact with the medium. Single spore cultures were obtained by the ordinary plating method, using spores deposited on a sterile cover glass.

The cultures derived from single spore isolations give rise to hyphae and sclerotia morphologically similar to those obtained in cultures derived from sclerotia from *Vigna*, *Arachis* and *Oryza*. This affords definite proof, and confirms the work of other writers, that *Corticium vagum* is the perfect stage of *Rhizoctonia solani*.

Mycelium.

In culture, the strains isolated from the different hosts behaved similarly and only minor differences such as were noted by Britton-Jones (2) and others were noted. On maize meal agar growth is rapid. At first the hyphae are colourless and adhere closely to the surface of the medium and to the sides of the glass tube. In a few days, the older hyphae begin to change to a yellow-brown, and finally, a brown colour. The brown hyphae are long and septate with the septa 35–245 μ apart, and 8–12 μ in diameter. Young branches and hyphae at the advancing edge of the culture are hyaline and septate, the individual cells being 27–75 μ long and 6–10 μ broad, frequently slightly constricted at the septa. There is usually a definite constriction at the base of the branches and the first septum is from 2–10 μ from the point of origin on the parent hyphae. The mature brown hyphae are thick-walled, rigid and uniform in diameter and the constriction at the base is not so evident.

Varying amounts of colour are developed in the media of cultures of the different strains. Most colour is produced by the strain from paddy, the medium of old cultures being of a dark-brown colour, almost purple-brown. This colour does not appear to be due to the intrusion of a pigment into the medium but to a deeper colour of the mature hyphae.

Sclerotia.

Young sclerotia arise on the surface of the media or on the sides of the tubes. They are first visible to the naked eye as small tufts or fluffy aggregations of hyphae. They are white at first but later become brown or purple-brown, hard and compact. The young sclerotium consists

of interwoven hyphae composed of somewhat angular or lobulate cells, hyaline at first and later becoming brown (Pl. IX, figs. 8 and 9); the internal cells change colour first. The mature sclerotia resemble those in nature, but are usually more pulvinate but with flat bases on the medium or glass. They vary in size up to 5 mm. but may coalesce to form irregular masses up to 1 cm. in diameter. The surface is covered by a velvety felt of brown mycelium except at the base. In section the sclerotium has a uniform pseudoparenchymatous structure, there being no differentiation into cortex and medulla. The cells of the pseudoparenchyma are angular and measure up to 17μ in diameter (Pl. IX, fig. 10).

There is considerable variation in the size and number of sclerotia produced by the different strains in culture. The strain from paddy produces them most abundantly, whereas the strain from *Vigna* develops the largest. The sclerotia of the strain derived from spores of *Corticium vagum* are very small, rarely exceeding 2 mm. in diameter though they frequently coalesce to form irregular sheets or masses. The strain from plantain produces similar but slightly larger sclerotia which increase in size and coalesce to form large masses. These are coated with a velvety felt like the others, but the colour remains white for a much longer period. The felt consists of somewhat angular or lobulate cells similar to the interwoven hyphae which constitute a young sclerotium and illustrated in Pl. IX, fig. 9. The small sclerotia are similar in structure to the larger sclerotia of other strains. The strains from *Acacia* and groundnut develop larger sclerotia but not so large, as a rule, as those of the *Vigna* strain.

There are also slight variations in the amount of aerial mycelium produced, though, in general, on maize meal agar this is very scanty. The strain from *Vigna* has a greater tendency to produce aerial mycelium in old cultures than have the other strains, and this is increased when the strain was transferred to bovril agar.

Such and greater differences have been recorded by other workers with strains of *Rhizoctonia solani*, but these at present cannot be regarded as of any great systematic value.

VIABILITY OF SCLEROTIA

Sclerotia collected from *Vigna oligosperma* (then known as *Dolichos Hosei*) in October, 1919, and stored in a small corked tube in the laboratory were placed in a mixture of damp sand and dadap leaf previously sterilised, in September, 1925. In a few days they germinated and gave rise to a vigorous growth of mycelium on which sclerotia were later developed. Though kept dry for six years they had retained their vitality and germinated as soon as conditions became favourable.

Briton-Jones (3) in Egypt found that sclerotia failed to grow after being stored during four summer months. This result was attributed to desiccation. The facility with which sclerotia were germinated in Ceylon indicates that the sclerotia retain their vitality under dry conditions for a much longer period than is suggested by Briton-Jones's experiment.

INOCULATION EXPERIMENTS

Muller (7) gives a list of over 160 plants on which *Rhizoctonia solani* is parasitic. The object of these experiments was to determine to what extent the *Rhizoctonia* from *Vigna* was parasitic on plants suitable as cover crops and green manures. The strains from *Musa* and *Acacia* were not used in any of the inoculation experiments here described, as the identity of these strains was not determined until this paper was nearing completion.

R. solani has been regarded principally as a parasite on dicotyledonous plants, but its discovery on bent grass (*Agrostis*) and fescue (*Festuca*) by Oakley (9) in America and on paddy (*Oryza sativa*) and plantain (*Musa paradisiaca*) in Ceylon shows that the fungus is not limited to dicotyledonous hosts.

With Seedlings.

The seedlings used in these experiments were raised from seed disinfected with 0.1 per cent. corrosive sublimate solution and grown in pots of sterilised soil. The inoculations were made by transferring the fungus, together with a little of the medium from pure culture, on to healthy unwounded seedlings. During dry weather the pots were covered with bell jars in order to maintain a humid atmosphere. As controls, seedlings were grown under similar conditions but were not inoculated with the fungus. In no experiment did infection occur on any of the control seedlings, so details concerning the control plants have been omitted from the tables giving the results of the inoculation experiments in order to simplify them.

The results obtained when the strain from *Vigna oligosperma* was used, are given in table 1. Of the 24 species of plants experimented with, only one, *Camellia theifera* (tea), was unaffected by the fungus. The other species were attacked in different ways. The commonest effect was that known as "damping off." This was brought about by an invasion of the fungus into the stem or hypocotyl just above ground level, which caused a brown or blackish discoloration, extending for an inch or more up the young stem. A yellowish liquid was sometimes exuded as small shining globules from this discoloured zone. Consequent

to the attack, the tissues broke down and the mechanical support was weakened with the result that the plants toppled over at this point. Later, all parts of the plant were invaded by the fungus. Fig. 1, pl. VII, shows the effect of the strain from *Vigna* on French beans forty-eight hours after inoculation. Fig. 2 is of the same plants two hours later, and shows the characteristic collapse of "damped off" seedlings. Damping off was observed with seedlings of *Albizzia moluccana*, *Clitoria cajanifolia*, *Crotalaria verrucosa*, *Dolichos lablab*, *Gliricidia maculata*, *Gossypium*, *Indigofera sumatrana*, *Phaseolus lunatus*, *P. vulgaris*, *Sesbania aculeata*, *Tephrosia Hookeriana*, *Vigna Catjang* and *V. oligosperma*.

In some cases infection resulted in a "ringing" of the plant. This occurred with more woody seedlings and was probably only a variation of the commoner "damping off." Infection occurred at or just above ground level and the cortical tissues became blackened and depressed. This depression was bordered above and below by a swollen callus similar to what occurs after mechanical ringing. The plants usually lived for a short time after the callus was visible, but ultimately they withered and died though they did not fall over. Such ringing was observed on *Sesbania aculeata* (Pl. VII, fig. 4) after inoculation with the strain from *Vigna*, and on cotton, one month old, inoculated with the strain from paddy.

This type of lesion has been described by Petch (12) and others on tea seedlings. Such lesions on tea seedlings have been attributed to several causes, but, as these experiments show that tea seedlings are not attacked by *Rhizoctonia solani*, it would appear that this fungus is not one of the causes of the tea seedling disease.

The third manner in which seedlings were attacked was similar to that which occurs on mature *Vigna* plants. Instead of penetrating the tissues at ground level the fungus overran the plant and penetrated the younger and more succulent tissues of the stem and leaves. This resulted in what may be termed a stem and leaf rot. The attacked parts became flaccid, blackened and slimy. The seedlings wilted; the rotting tissues became covered with hyphae, and sclerotia were frequently formed on them. This form of attack has been noted on seedlings of *Arachis hypogaea*, *Calopogonium mucunoides*, *Cassia hirsuta*, *Centrosema pubescens*, *Crotalaria incana*, *Indigofera arrecta*, *Melilotus alba* var. *annua*, *Nicotiana tabacum* and *Tephrosia candida*.

The experiments in which were used the strains derived from sclerotia on *Oryza sativa* and from *Corticium vagum* spores on *Arachis* gave similar results to those obtained when the strain from *Vigna* was used. These results are given in concise form in tables 2 and 3 respectively. The strain from *Oryza* was more virulent than either of the other strains

on paddy. Many of the seedlings inoculated with this strain died out and many others developed dark-coloured lesions on the base of the leaf sheath just above the water level of the pots. The attacked leaves withered and turned almost white in colour. Sclerotia developed on the sides of the pot above the water. With other strains no seedlings died, though the leaf sheaths were penetrated and the lower leaves withered.

With Infected Soil.

The seedlings which had been killed by the strain from *Vigna* were mulched into the soil in which they were grown. Later, this soil was sown with seed previously disinfected with corrosive sublimate solution. Control experiments were made by sowing similar seed in sterile soil. Seeds of cow pea, French bean and Lima beans were used for these experiments.

1. Of twenty seeds of *Phaseolus vulgaris* sown in infected soil, not one seedling had appeared above ground after 10 days when the control plants were nearly 10 inches high. The seeds were then dug out of the infected soil and examined. Three had put out roots before being killed, the others had not begun to germinate and mycelium was found in abundance within the seed coat.

2. Eight seeds of *Phaseolus lunatus* were sown in infected soil and all germinated. Four seedlings rotted before they lifted their cotyledons; the other four grew to a height varying from 8-16 inches before being damped off. Seven of the eight seeds sown in the control pot germinated and produced healthy plants.

3. Thirteen seedlings of *Vigna Catjang* growing in infected soil appeared above ground four days after sowing. After one month five of the seedlings remained healthy; the others were damped off within six days of making their appearance above ground. Sclerotia were found on the diseased seedlings. All the control seedlings remained healthy.

With Cuttings.

Damping off of cuttings by *Rhizoctonia* is a well-known phenomenon in the propagating house (4), and it seemed advisable to determine whether certain plants recommended as cover crops and usually propagated by cuttings were susceptible to this form of attack. For this purpose cuttings of *Indigofera endecaphylla*, *Centrosema pubescens* and *Vigna oligosperma* were used, infected soil being used as in the previous experiments.

1. Eleven cuttings of *Indigofera endecaphylla* were planted in a pot of infected soil on 29th October, 1925. All cuttings struck and grew up unaffected by the fungus. Healthy plants were also raised in the control pot. These were inoculated on 2nd February, 1926, with mycelium and sclerotia from culture. On 25th February, 1926, no discoloration was found about the inoculated region and there was no trace of penetration by the fungus. The plants remained healthy.

2. Cuttings of *Centrosema pubescens* were planted on 25th September, 1925, in infected soil in a pot. All produced healthy plants as did those planted in sterilised soil. Healthy plants were also inoculated directly from culture, but they failed to take infection.

3. Healthy cuttings of *Vigna oligosperma* were planted on 25th September, 1925, in infected soil. They struck readily. The disease took the same form as it does in the field. The cuttings were not damped off nor did the plants die out.

TABLE 1

Inoculation experiments on seedlings with the strain from *Vigna oligosperma* from pure culture

Date of sowing.	Date of inoculation.	No. of plants inoculated.	Place of inoculation.	Positive.	Negative.	Nature of infection and remarks.
<i>Albizzia moluccana.</i> 2.9.25	25.9.25	6	Ground level	5	1	Damped off within 7 days.
<i>Arachis hypogaea</i> , (Groundnut). 29.8.25	9.9.25	5	G. L.	3	2	Stem and leaf rot. Plants died within 14 days.
<i>Camellia theifera</i> , (Tea). 23.12.24	14.7.25	10	G. L.	—	10	—
23.12.24	14.7.25	9	G. L. at wounds.	—	9	—
10.12.25	12.1.26	7	G. L.	—	7	—
<i>Calopogonium mucunoides.</i> 17.7.25	30.7.25	24	G. L.	18	6	Stem and leaf rot. Plants died within 6 days.
17.7.25	26.8.25	20	Leaves and shoots	20	—	4 plants died within a week, others within 14 days.
17.7.25	14.9.25	7	G. L.	2	5	5 plants remained healthy after one month.
<i>Cassia hirsuta.</i> 14.9.25	14.10.25	14	G. L.	14	—	Leaf and stem rot. All dead in 14 days.

Date of Sowing.	Date of inoculation.	No. of plants inoculated.	Place of inoculation.	Positive.	Negative.	Nature of infection and remarks.
<i>Centrosema pubescens.</i> 29.8.25	11.9.25	8	G. L.	8	—	Leaf and stem rot. All seedlings collapsed in 10 days.
<i>Clitoria cajanifolia.</i> 1.9.25	25.9.25	11	G. L.	11	—	Damped off. Dead within 10 days.
	1.9.25	5	G. L.	—	5	—
<i>Crotalaria incana.</i> 17.7.25	25.8.25	20	G. L.	20	—	Leaf and stem rot. All dead within 7 days.
	17.7.25	13	G. L.	10	3	Leaf and stem rot. Deaths occurred within 10 days.
	17.7.25	3	G. L.	2	1	Leaf and stem rot.
<i>Crotalaria verrucosa.</i> 10.9.25	25.9.25	13	G. L.	13	—	Damped off.
	10.9.25	16	G. L.	9	7	Damped off.
<i>Dolichos lablab.</i> 13.7.25	21.7.25	9	Just above Cotyledons.	7	2	Damped off within 3 days.
	13.7.25	5	On leaves.	5	—	Leaf and stem rot.
	22.7.25	23	G. L.	22	1	Damped off within 4 days.
<i>Gliricidia maculata.</i> 2.9.25	11.9.25	12	G. L.	12	—	Damped off in 4 days.
	2.9.25	12	G. L.	—	12	—
<i>Gossypium sp.</i> , (cotton, Zululand hybrid). 9.7.25	20.7.25	16	G. L.	14	2	Damped off; dead in 8 days.
<i>Indigofera arrecta.</i> 29.8.25	15.10.25	16	G. L.	14	2	Leaf and stem rot.
<i>Indigofera sumatrana.</i> 10.9.25	15.10.25	24	G. L.	23	1	Damped off in 7 to 14 days.
<i>Melilotus alba</i> , var. <i>annua</i> , (Hubam clover). 18.9.25	19.10.25	Numerous.	G. L.	Many.	Many.	Inoculum placed on soil. Younger seedlings only affected by rot.
<i>Nicotiana tabacum</i> , (Tobacco). 18.9.25	19.10.25	Numerous.	G. L.	Many.	Many.	As <i>Melilotus</i> .
<i>Oryza sativa</i> , (Paddy). 20.1.26	4.2.26	Numerous.	Just above ground level	Numerous.	Few.	Brown discolouration at point of inoculation. Hyphae penetrated outer leaf base only.
<i>Phaseolus lunatus</i> , (Lima bean). 4.11.25	13.11.25	4	G. L.	4	—	Damped off, 2-5 days.
	3.11.25	6	G. L.	6	—	—
<i>Phaseolus vulgaris</i> , (French bean). 7.8.25	22.8.25	22	Leaves and shoots.	10	12	Leaf and stem rot and damping off, 11-16 days.
	29.8.25	11	G. L.	11	—	Damped off, 2-3 days.
	29.8.25	9	Just above the cotyledon.	9	—	Damped off.

Date of sowing.	Date of inoculation.	No. of plants inoculated.	Place of inoculation.	Positive.	Negative.	Nature of infection and remarks.
<i>Sesbania aculeata</i> .						
2 9.25	8.9.25	13	G. L.	13	—	Damped off.
2.9.25	20.10.25	24	G. L.	23	—	Ringed. Plants died after 14-40 days.
<i>Tephrosia candida</i> .						
29.8.25	9.9.25	9	G. L.	9	—	Leaf and stem rot.
29.8.25	19.10.25	12	G. L.	2	10	Leaf and stem rot; 10 remained healthy.
<i>Tephrosia Hookeriana</i> .						
15.9.25	14.10.25	16	G. L.	13	3	Damped off within 15 days.
<i>Vigna Catjang</i> , (Cow pea).						
9.7.25	22.7.25	8	Just above cotyledons.	8	—	Damped off within 6 days.
9.7.25	22.7.25	4	On leaves.	4	—	Leaf and stem rot.
29.7.25	22.8.25	14	G. L.	9	5	Damped off within 10 days.
<i>Vigna oligosperma</i> .						
21.10.25	13.11.25	5	G. L.	4	1	Damped off in 3-6 days.

TABLE 2

**Inoculation experiments on seedlings with the strain from paddy
from pure Culture**

<i>Arachis hypogaea</i> , (Groundnut).						
8.1.26	29.1.26	4	Ground level.	4	—	Only one plant died. The others became infected on the leaves and stems but survived attack.
<i>Camellia theifera</i> , (Tea).						
10.12.25	1.2.26	6	G. L.	—	6	—
<i>Dolichos lablab</i> .						
12.1.26	29.1.26	7	G. L.	6	1	Damped off within 5 days.
<i>Gossypium sp.</i> , (Cambodia cotton).						
8.1.26	18.1.26	6	G. L.	6	—	Damped off within 3 days.
8.1.26	9.2.26	7	G. L.	7	—	Ringed. Plants died within 8 days.
<i>Oryza sativa</i> , (Paddy).						
20.1.26	4.2.26	Numerous.	G. L.	Numerous.	Few.	Infection occurred at the point of inoculation. A few seedlings died out, but in most cases only the outer leaf bases were penetrated.
<i>Phaseolus vulgaris</i> , (French bean).						
28.1.26	4.2.26	8	G. L.	4	4	Damped off in 4 days.
<i>Vigna Catjang</i> , (Cow pea).						
29.1.26	4.2.26	10	G. L.	7	3	Damped off in 5-9 days.
<i>Vigna oligosperma</i> .						
29.1.26	2.3.26	Numerous.	G. L.	Numerous.	—	Many were damped off but others were affected with leaf and stem rot

TABLE 3

Inoculations on seedlings with strain from *Corticium vagum* spores

Date of sowing.	Date of inoculation.	No. of plants inoculated.	Place of inoculation.	Positive.	Negative.	Nature of infection and remarks.
<i>Arachis hypogaea</i> , (Groundnut).						
8.1.25	25.1.26	4	G. L.	2	2	Damped off within 4 days.
<i>Dolichos lablab</i> .						
12.1.26	26.1.26	7	G. L.	5	2	Damped off in 2-5 days.
<i>Gossypium</i> sp., (Cambodia cotton).						
8.1.26	18.1.26	10	G. L.	10	—	Damped off within 3 days.
<i>Phaseolus vulgaris</i> , (French bean).						
28.1.26	4.2.26	6	G. L.	3	3	Damped off in 5-10 days.
<i>Vigna Catjang</i> , (Cow pea).						
29.1.26	4.2.26	12	G. L.	12	—	Damped off within 3 days.
<i>Vigna oligosperma</i> .						
21.10.25	26.1.26	8	G. L.	8	—	Leaf and stem rot. The plants did not dis.

GENERAL

Duggar (4) has expressed the opinion that *Rhizoctonia solani* exists as a saprophyte in most arable soils throughout the United States and Canada, and under certain conditions may attack many species of plants. *Rhizoctonia solani* has now been recorded from most parts of the world and the number of plants on which it has been recorded is extraordinarily large. The fact that the fungus occurs in the soil renders necessary a detailed study of the conditions which favour the parasitic habit in order that its ravages may be controlled. The discovery of the fungus as a parasite under different conditions of climate and habitat renders this problem very complex.

Investigations into the relationship between temperature and the parasite have been made by numerous workers. Gratz (6), for a strain isolated from cabbage in America, gives the minimum, optimum and maximum temperatures for growth as 9°, 22-26° and 31° C. respectively. Balls (1) for a strain isolated from cotton in Egypt gives 23° and 50° C. as the optimum temperature of growth, and death point respectively. It is evident that the ordinary temperature in tropical climates is about the optimum temperature of growth for the fungus; this is shown by the rapid growth of the fungus in culture at ordinary room temperature.

Gratz also gives the pH range for growth as being from approximately 2.0 to about 10.4 with an optimum of about 6.2. This range

covers all degrees of acidity likely to be met with in ordinary soils, so that a method of control by altering the pH of the soil or host plant appears out of the question.

Rhizoctonia solani demands good aeration for its optimum growth and for this reason, growth is usually feeble and slow on liquid media. In the inoculation experiments on paddy the fungus grew upwards and away from the water ; there was no growth either in or on the surface of the water. Sclerotia were formed above the water level on the leaves or on the side of the pot,

As the fungus is essentially a soil dweller and needs a free oxygen supply, its presence as a natural infection on paddy is somewhat surprising owing to the conditions under which paddy is grown. So far the fungus has only been found once on this host in Ceylon, and then neither the source nor time of infection could be ascertained. In view of the oxygen requirements of the fungus it would appear improbable that paddy will become infected frequently from the soil, unless the soil conditions are rendered such as will allow rapid growth of the fungus and infection of the plants before the fields are flooded.

During the course of the inoculation experiments it was noted that the fungus was very susceptible to moisture conditions, particularly atmospheric conditions. Infection occurred most readily when atmospheric conditions were moist. For this reason, bell jars were used to cover the plants used for the inoculation experiments during dry weather, in order that the air around the plants would be humid. It was noticed that where the plants were affected by a leaf and stem rot, the advance of the disease was checked whenever the bell jars were removed during dry weather, and that the fungus renewed its attack only after bell jars were replaced. When the attack took the form of damping off, the removal of the bell jars had little effect if the seedlings showed signs of infection before the removal of the jars. Seedlings growing on infected soil, however, were not so readily damped off in a dry atmosphere as when the conditions were more humid.

The relationship between the attack by this fungus on *Vigna* and the humidity of the atmosphere is very noticeable in the field. During wet weather the areas known to be infected become very thin owing to the destruction of the leaves, and gaps of increasing size are noticeable in the cover. As conditions become drier these gaps become filled in again owing to the new growth of the *Vigna*, and the infected areas are not easy to locate.

The amount of water vapour in the atmosphere surrounding the plants appears to be of greater importance than the amount of moisture

in the soil as a factor in determining the liability of plants to attack by this fungus. Practically any combination of soil temperature and soil moisture favourable for the growth of the host plants is also favourable for the fungus. A dry atmosphere, however, so long as the roots are supplied with sufficient water inhibits infection by the fungus to some extent without seriously reducing the growth rate of the plant.

Certain plants, though susceptible to attack as young seedlings, become immune when older. It will be seen from Table 1 that seedlings of *Clitoria cajanifolia* 4 months old, and *Gliricidia maculata* 6 weeks old, were unaffected by the fungus though younger seedlings had been destroyed, and that the older seedlings of *Calopogonium mucunoides*, *Crotalaria verrucosa*, and *Tephrosia candida* were attacked to a much less extent than were younger seedlings of the same species. A similar phenomenon has been observed by other workers on cotton. Attempts to infect mature plants of *Indigofera endecaphylla* and *Centrosema pule-scens* in pots and in the field failed though young seedlings were susceptible to the disease.

CONTROL

The control of *Rhizoctonia solani* as a seedling disease has proved particularly difficult owing to the fact that the fungus lives in the soil. Sterilisation of soil, except on a small scale, to destroy the fungus before the seeds are sown is impracticable, particularly for small growers in the tropics. The importance of cultural methods in the control of this disease must therefore be strongly emphasised. The two main objects to be kept in view are (1) the avoidance of attack if possible, and (2) the promotion of growth of the seedlings so that they may rapidly pass the susceptible stage.

Attack may be avoided if the fungus in the soil is first destroyed, and only clean uninfected planting material is used for sowing. Sterilisation of the soil will destroy the fungus, but unfortunately sterilisation is as yet impracticable except on a small scale. Nevertheless, care should be taken to ensure the use of healthy planting material. The risk of using infected seed is relatively small so long as sclerotia are not mixed with the seed. With tubers, such as the potato, there is a greater risk of introducing infectious matter with the planting, and the presence of sclerotia on the tubers results in an early spread of the fungus to the young shoots.

The use of disinfectants for the cleansing of planting material has not proved entirely successful. Schander and Richter (14) after an extensive series of field experiments obtained very disappointing results from the 15 fungicides they used ; the disinfection exerted no appreciable

effect on the incidence of the disease. The use of fungicides applied to the surface of the soil has proved more beneficial with seedlings. Rosen (13) completely arrested "damping off" of cotton seedlings by *R. solani* by an application of 0.25 per cent. uspulum at the rate of 1 gallon per sq. ft. of soil. This treatment, however, amounts at least to a partial sterilisation of the soil. Gratz (6) obtained similar beneficial results against a strain of *Rhizoctonia solani* on cabbage seedlings by drenching the soil with formaldehyde, but calcium hypochlorite and Cheshunt compound were not equally effective.

In some cases attack may be averted by varying the time of sowing. Briton-Jones (3) concerning the time of sowing cotton seed in Egypt states: "Generally speaking, cotton sown in February or any time up till about March 15th is badly attacked by sore shin. At this period the amount of sore shin decreases as the season advances up till the middle of April." This is attributed to the fact that the increase in temperature during these months results in an acceleration of the growth of the seedling together with a drying up of the upper layer of the soil which has an inhibiting effect on the growth of the fungus. Gratz, working with cabbage seedlings, arrived at the conclusion that a low temperature and a dry surface (covering the beds with a layer of sand $\frac{1}{4}$ inch thick) may reduce the incidence of the disease or delay it but not sufficiently for control purposes. The effect of a dry surface is to reduce the humidity of the atmosphere at ground level, and as already pointed out from observations made during the inoculation experiments described here, the atmospheric humidity is an important factor in determining the virulence of attack by this fungus.

Soil known to be infected by *R. solani* should not be used for nursery beds. Where the use of infected soil is unavoidable and sterilisation of the soil is impracticable or uneconomic, efforts should be made to obtain the maximum rate of growth of the seedlings in order to bring them to a resistant stage of development as soon as possible. Overcrowding should be avoided, the plants should be well spaced and infected plants removed and burnt immediately they are noticed. Humid conditions should be avoided as far as possible in order to retard the growth of the fungus. The use of infected soil for seed is certain to result in losses, and these can be reduced to a minimum only by careful attention and the application of sound agricultural principles.

With plants which are liable to attack at all ages, control is still more difficult. Rotation of crops can be of little value against this disease as the fungus may remain alive in the soil for many years. *Vigna oligosperma* on which the disease occurs principally at the present time

in Ceylon is grown as a semipermanent crop. The character which renders the plant eminently suitable as a cover crop to prevent erosion, viz., its mat habit, is one which also favours the growth of the fungus. This fungus, however, does not kill the host in Ceylon and attention is drawn to the presence of the disease only in wet weather. The disease also occurs in Dutch East Indies (5) where the damage caused by the fungus is more marked. The production of sclerotia on the diseased tissue and their resultant accumulation in the soil renders the soil highly infectious. Moreover, the infected areas become enlarged with succeeding attacks during wet weather and a larger area of soil becomes badly infected. If, then, it should become necessary to replace the *Vigna* at some later date with another crop, the fungus will certainly have to be reckoned with if that crop is grown from seed.

The disease on *Vigna* was first noted on a demonstration plot of *Vigna* in 1919 at the Experiment Station, Peradeniya, and the plants were rooted out later. In 1922, the Manager of the Experiment Station, not knowing the history of that plot, tried to establish *Indigofera arrecta* from seed on that ground. In that, he had considerable difficulty and it was only after some time and by sterilising the soil with boiling water and by burning rubbish on it that he ultimately succeeded. For this reason, active steps should be taken to control the disease whenever it occurs.

Diseased *Vigna* plants and others of like habit should be removed from the area known to be infected and burnt. In marking out the infected area a belt of apparently healthy plants should be included. If it is necessary to remove the plants from that area in order to burn them, the plants should be carried in tins so that the risk of sclerotia being dropped on clean soil may be avoided. The cleaned area should then be planted up with other plants such as *Indigofera endecaphylla* or *Centrosema pubescens* found to be immune. The latter is recommended by Gandrup (5) who records seeing *Centrosema* growing healthy on land on which *Vigna* suffered badly from disease. Both plants proved immune in the inoculation experiments carried out at Peradeniya though they have not been tried out under field conditions in Ceylon. No doubt other suitable cover plants will also be found which are immune to this disease.

The importance of using healthy planting material cannot be too strongly emphasised when dealing with this disease and where estates are being planted up in *Vigna* from cuttings, every care should be taken to prevent the introduction of the parasite with the planting material.

SUMMARY

1. The occurrence of *Corticium vagum* B. and C. and its vegetative mycelium (*Rhizoctonia solani* Kühn) on *Vigna oligosperma*, *Arachis hypogaea* (groundnut), *Oryza sativa* (paddy), *Musa paradisiaca* (plantain) and *Acacia decurrens* in Ceylon is recorded.
2. Minor differences occur between the various strains.
3. The fungus is parasitic on seedlings of many plants suitable for cover crops. Adult plants, however, are not equally susceptible.
4. Methods of control of the disease are discussed.

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EXPLANATION OF PLATES

Plate VI. *Vigna oligosperma* attacked by *Rhizoctonia solani* Kühn.

Plate VII, Fig. 1. French beans inoculated with *R. solani*, photographed 48 hours after inoculation. $\times \frac{1}{3}$.

Fig. 2. The same plants shown in fig. 1, photographed 2 hours later. $\times \frac{1}{3}$.

Fig. 3. Control plants. $\times \frac{1}{3}$.

Fig. 4. *Sesbania aculeata* inoculated with *R. solani*. Nat. size.

Plate VIII, Fig. 1. *R. solani* on paddy. Nat. size.

Fig. 2. *Corticium vagum* on *Arachis hypogaea*. Nat. size.

Fig. 3. Pure culture of *R. solani* derived from spores of *Corticium vagum*. Nat. size.

Fig. 4. Pure culture of *R. solani* from plantain. Nat. size.

Fig. 5. Pure culture of *R. solani* from paddy. Nat. size.

Fig. 6. Pure culture of *R. solani* from Vigna. Nat. size.

Fig. 7. Section through sclerotium of *R. solani* from *Vigna oligosperma*. $\times 40$.

Plate IX, Figs. 1 & 2 Basidia of *Corticium vagum* B. & C. from leaves of *Arachis hypogaea*. $\times 950$.

Fig. 3. Basidiospores. $\times 950$.

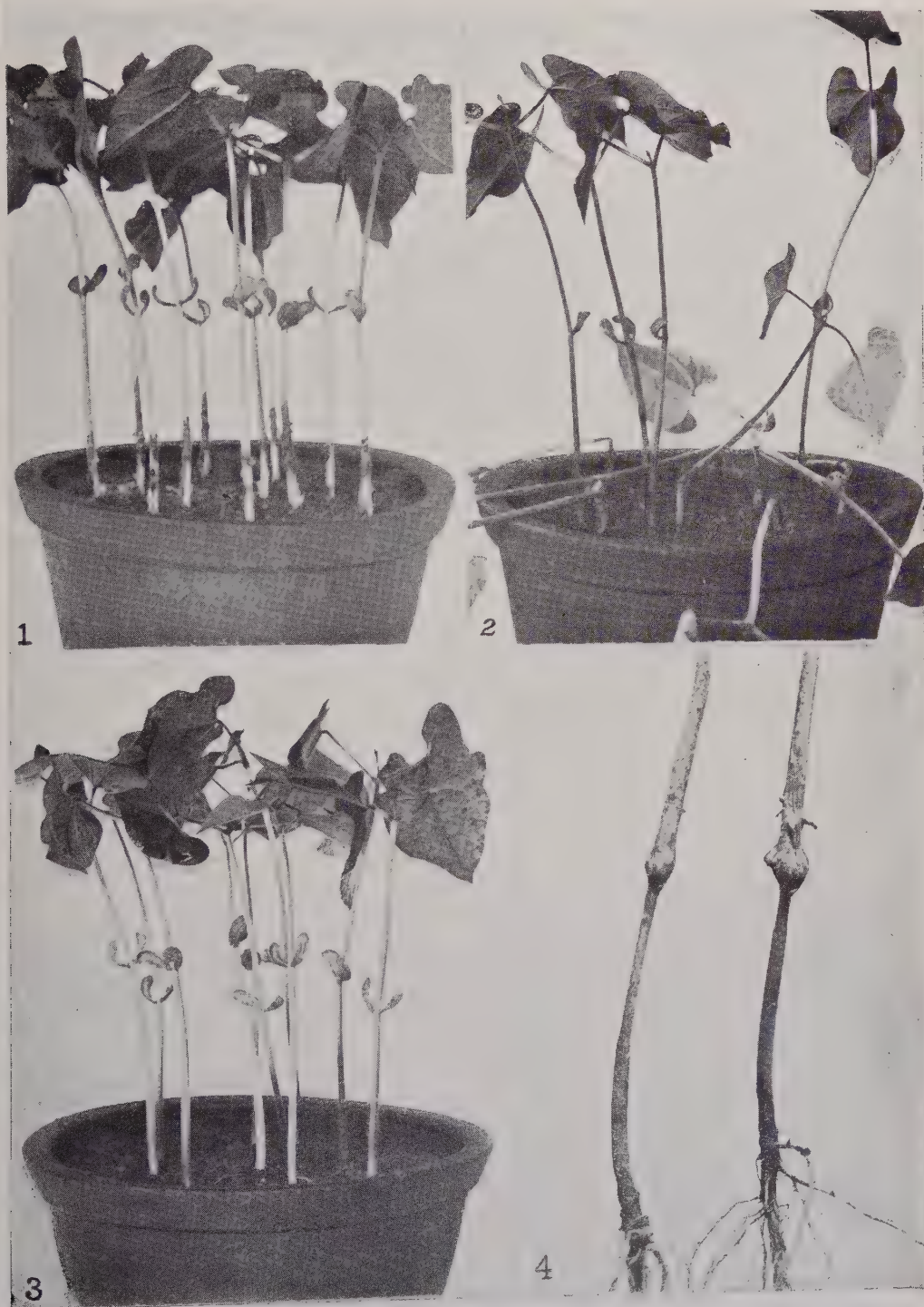
Fig. 4. Basidiospores germinated in water, 24-36 hours, $\times 950$.

- Fig. 5. Basidiospores germinated in maize meal agar, showing a branch near the base of the germ tube. $\times 950$.
- Fig. 6. Basidiospore with germ tube arising from the side of the spore. $\times 950$.
- Fig. 7. Basidiospore germinated at both ends. $\times 950$.
- Figs. 8 & 9. Hyaline lobulate cells from young sclerotium. $\times 475$.
- Fig. 10. Cells from the interior of mature sclerotium. $\times 475$.
- Figs. 11 & 12. Anastomoses of vegetative hyphae. $\times 630$.
- Fig. 13. Superficial hyphae of *R. solani* from *Vigna oligosperma*. $\times 630$.
- Fig. 14. Internal hyphae from leaf of *Vigna oligosperma*. $\times 520$.

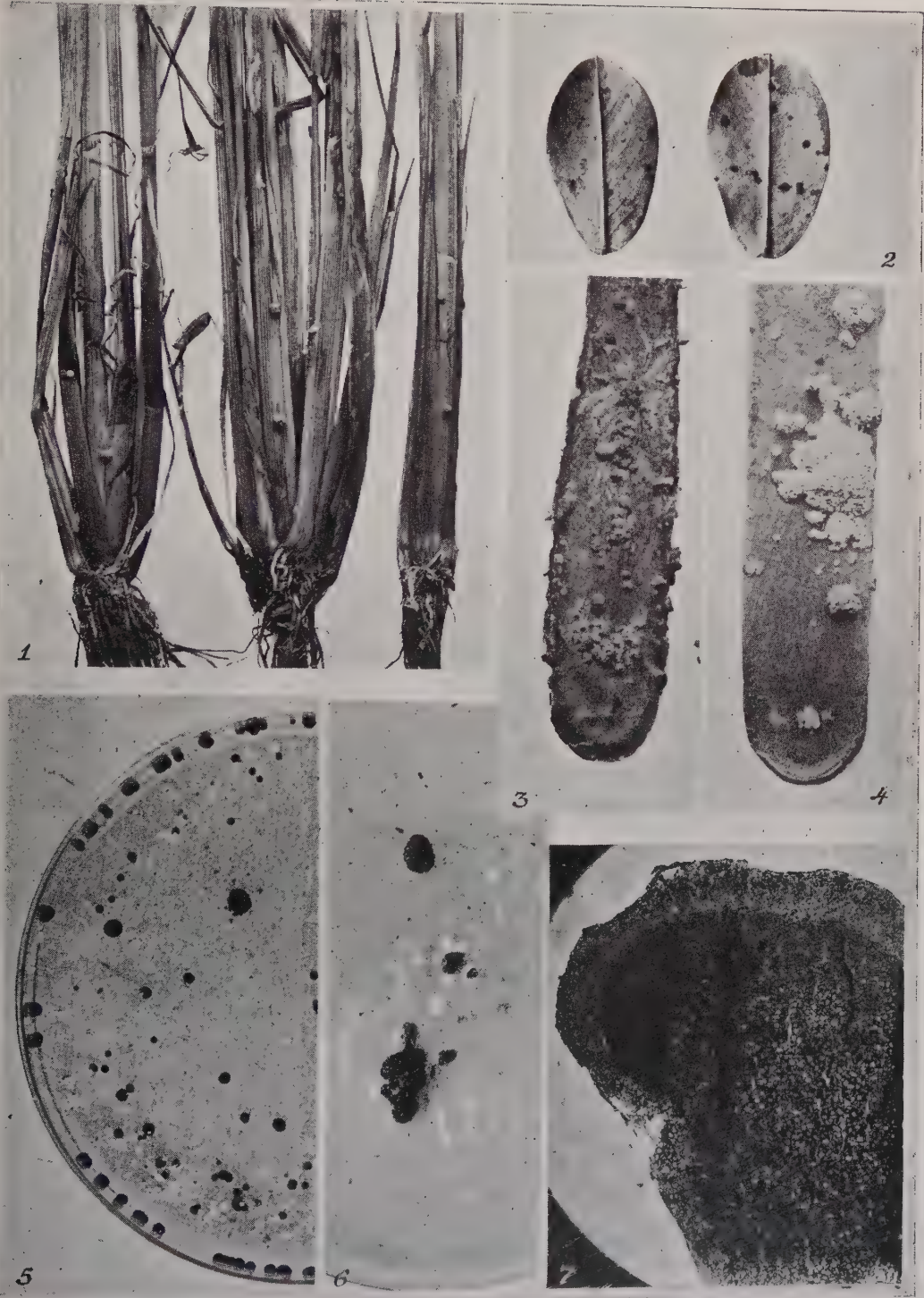
(Received for publication June, 1926).



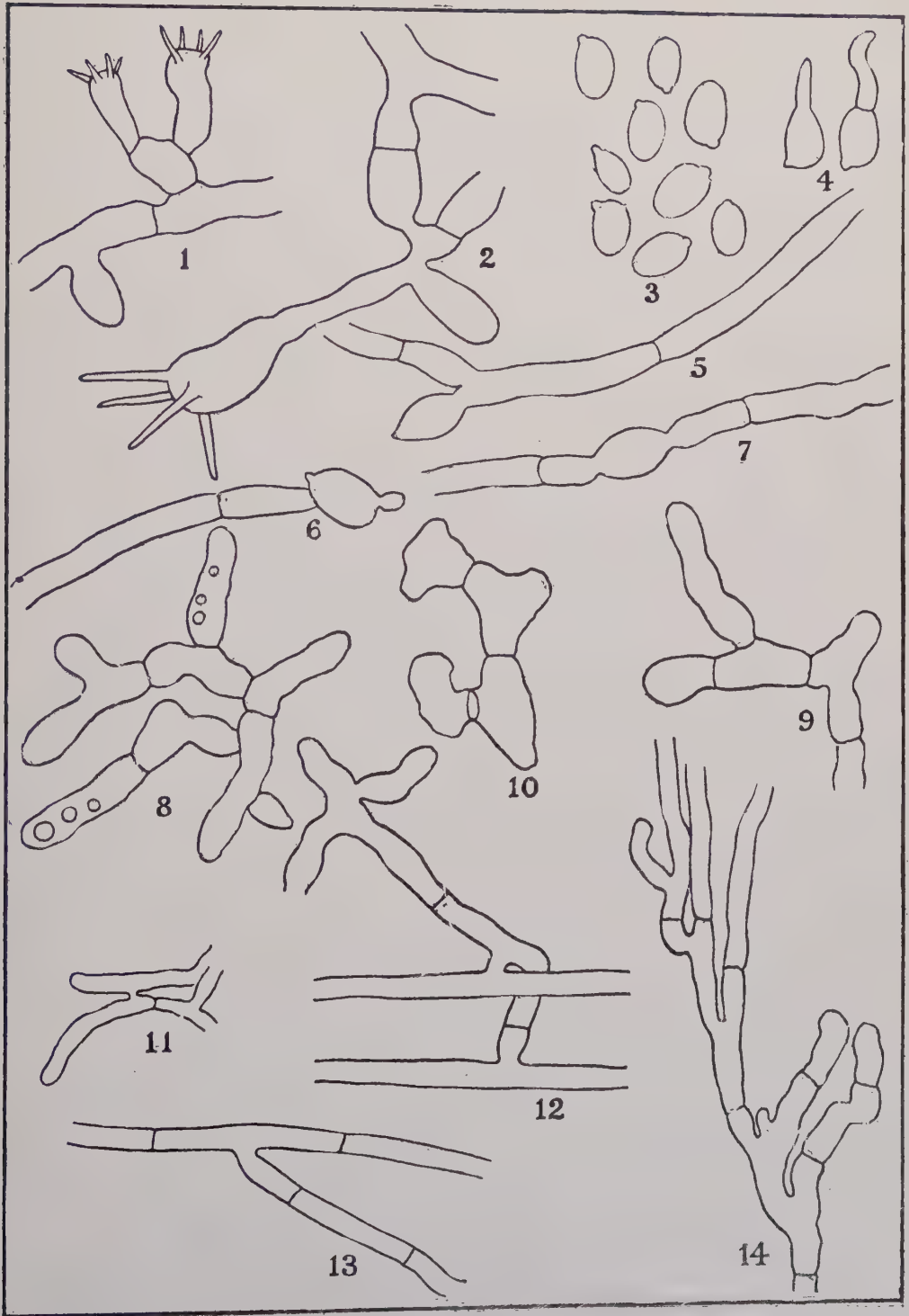
Photo by L. S. Bertus.



Photos by L. S. Bertus.



Photos by L. S. Bertus.



Bacterial Leaf Spot of Betel

BY

C. Ragunathan, Dip. Ag. (Poona)*

Assistant in Mycology, Department of Agriculture, Ceylon

WITH TWO PLATES

The leaf disease of betel (*Piper betle*), which forms the subject of this paper, has been known in Ceylon for many years. It appears to have been first recorded in 1896. Since then, specimens of betel plants affected by this disease have been sent to the Agricultural Department from various districts of the Island. This disease has been recorded from Anuradhapura, Panula, Kadugannawa, Galle, Padukka, Veyangoda, Kosgama, Gampaha, Madulsima, Urugala, Katugastota, Peradeniya Experiment Station and from several other places in the low-country.

In recent years it has done considerable damage to cultivation in several places in the low-country. It is, as a rule, most prevalent during the monsoons.

SYMPTOMS

The first indications of the disease are minute water-soaked spots on the under surface of the leaves between the veins. Later the spots become visible on the upper surface as dark-coloured rounded or angular areas surrounded by yellow zones. On the lower surface the surrounding zones have a water-soaked appearance. The centres of the spots are mottled brown, later becoming black and rotten. The yellow zone of the upper surface corresponds with the water-soaked area on the lower surface of the leaf. Individual spots at an early stage of infection measure up to 5 mm. in diameter. Later, owing to the spread of the disease through the tissues or to a coalescence of spots originating from distinct infections, large irregular dead areas are formed. Sometimes, the central dead tissues of old lesions fall out, leaving a hole through the leaf. When, as frequently happens, the lesions are marginal, the leaves

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present a torn appearance. On badly infected vines spotted leaves are distinctly yellow and fall off. Under very humid conditions a gummy substance which swarms with bacteria appears on the undersurface of the diseased leaves. Infections sometimes occur on the stem, though the leaf is the common place of infection. Following the fall of diseased leaves, badly infected vines usually die.

MICROSCOPIC EXAMINATION

When fresh diseased leaves are cut with a razor for sectioning a viscid fluid teeming with bacteria slowly exudes. These bacteria are non-motile, non-flagellate, rod-shaped or filamentous, and usually solitary or in pairs. They measure $0.5 \times 1.5-2.5\mu$ when stained with carbol fuchsin. Similar bacteria are found in large numbers throughout the diseased tissue.

An examination of young lesions indicates that infection invariably occurs on the under surface and at the stomata. Fig. 6, Plate XI, is a microphotograph of a section through a very young lesion, and the bacteria may be seen in masses in the stomatal cavities. From the stomatal cavities the bacteria pass *via* the intercellular spaces to the mesophyll of the leaf (Fig. 4, Plate XI) and invade the cells. The cell walls become brown and finally collapse and a slimy mass swarming with bacteria is produced. The invasion continues through the mesophyll and palisade layers but does not progress, as a rule, into the cells of the upper epidermis as may be seen from fig. 7, Plate XI. The collapse of the cells of the infected tissues results in a reduction of the thickness of the leaf at the infected places. This is not very evident to the naked eye but is well shown in figs. 5 and 8, Plate XI.

The presence of bacteria in large numbers was the most constant character of all the diseased leaves examined. Fungi were rarely found, never in young lesions, and bacteria were always associated with the disease symptoms. Experiments were therefore carried out to determine the pathogenicity of the bacteria.

PATHOGENICITY

Two diseased betel leaves obtained from the Experiment Station, Peradeniya, were washed with 1 per cent. mercuric chloride and distilled water. The diseased portions were cut out with a sterile scalpel and crushed with sterile water in a sterile watch glass. On 5.1.25 ten inoculations were made on the lower surface of three healthy betel leaves *in situ* on a healthy plant; the leaves were previously wounded with a sterile needle. Typical symptoms of the disease developed on all three

leaves in 5 places, after 17 days. Four inoculations were also made through wounds on the upper surface but none of these was successful.

The lesions resulting from successful inoculation were examined microscopically. No evidence of any fungus growth was found and the lesions abounded with bacteria similar to those observed in the field specimens. Further inoculations were made on two healthy leaves *in situ* on 2-4-25, with material obtained from young lesions on plants obtained from Katugastota. Three inoculations were made on one leaf through wounds and five inoculations on another but unwounded leaf. In both cases the inoculations were on the under surface of the leaves. The plant was kept in a moist chamber for three days before being put in the open. On 20-4-25 typical symptoms of the disease appeared at two of the inoculated points on the wounded leaf.

Bacterial isolations were made from these young lesions. The isolation plates developed numerous colonies of a yellow bacterium which was grown in pure culture.

ISOLATIONS

In addition to the isolation already mentioned, five further isolations were made from fresh material collected at the Experiment Station, Peradeniya, and from Katugastota.

Isolation 1. Young spots on diseased leaves collected on the Experiment Station, Peradeniya, after washing in 0.1 per cent. solution of mercuric chloride and distilled water, were crushed in sterilised tubes with distilled water and allowed to stand for about half an hour. Afterwards the pieces of leaf were carefully removed with a sterile platinum loop and dilution plates were poured. The medium used was Duggar's standard nutrient agar.

Isolation 2 was carried out in the same way as number 1 with material from the same place.

Isolation 3 was carried out in the same way as number 1, but the material used for isolation was obtained from Katugastota.

Isolation 4. Diseased specimens from Katugastota with young lesions were washed in 0.1 per cent. corrosive sublimate solution and distilled water and the lesions were cut with a sterile pair of scissors and direct transfers were made to tubes of Molisch gelatine and maize agar.

Isolation 5. Diseased specimens from the Experiment Station, Peradeniya, were disinfected as in number 1 and young lesions were crushed with distilled water and healthy plants were inoculated in the plant-house with the extract. The lesions resulting from these inoculations were treated as the material used for Isolation No. 1. Duggar's standard nutrient agar and maize agar were used for this isolation.

Poured plates from isolations 1, 2, 3 and 5 gave numerous similar colonies of yellow bacteria. The colonies were smooth, honey-yellow, entire and rounded. The same bacterium developed in the tubes of isolation 4, but two tubes of maize agar and one of Molisch gelatine were contaminated with a fungus growth of a species of *Gloeosporium*. The bacteria from all isolations were grown on various nutrient media with similar results.

GROWTH IN MEDIA

Cultures were grown at room temperature of 76° F. Periodic re-isolations were made in the course of the work to keep the cultures pure.

Duggar's standard nutrient agar. On this medium the colonies become visible after 18 hours, but later growth is not so rapid. The colonies are raised, glistening, honey-yellow, (Ridgway, Plate XXX) with no odour, and slowly liquefy the medium.

Maize meal agar. A viscid, honey-yellow, shiny raised mass appears in two days on this medium. In tubes that are kept slanted at an angle of 60° an effuse shiny mass flows down in a week. The medium does not change colour nor does it liquefy. There is no odour.

Molisch gelatine agar. The organism grows well in this medium. The point of inoculation becomes cloudy on the second day and the colony soon becomes honey-yellow in colour. Liquefaction starts in 4 days and is complete in 15 days. The honey-yellow viscid mass becomes dull yellow as liquefaction proceeds.

Steamed potato slants. On this medium the organism grows rapidly and forms an effuse honey-yellow viscid mass which gradually flows down the potato into the lower cavity of the Roux tubes. The medium becomes of a dull light brown colour. No marked dissolution of potato tissue occurs though the tissues shrivel up in 15 days.

Carrots. On steamed carrot the organism grows well and produces an effuse, smooth, viscid, honey-yellow mass. Owing to the natural colour of the carrots this mass appears somewhat reddish. There is no odour. The medium collapses as with potato slants, but does not change colour.

Cohn's solution. Growth is very poor. There is a white sediment on the surface after two weeks.

Betel leaf juice agar. Growth is very poor.

Ferri's solution. No growth.

Gelatine. In stab cultures on 2 per cent. gelatine, liquefaction becomes visible on the third day and progresses slowly. In some tubes the liquefaction is 4-5 mm. deep on the third day. The growth is more

napiform than crateriform. It takes 15 days for the complete liquefaction of the medium in the tube.

On slants, liquefaction is evident on the second day and is complete in a week. The increased rate of liquefaction in slant cultures may be due to the larger area of medium exposed to the action of the bacteria. There is a light yellow deposit in the medium.

Modified Uschinsky's solution. Growth is feeble.

Glycerine agar. No growth.

Bovril agar. In stab cultures there is a small light honey-yellow pellicle at the point of the stab after 24 hours. On the third day, there is a round shiny viscid honey-yellow mass on the surface of the medium. There is no growth in the medium along the stab.

On slants, the colony becomes visible after 24 hours. On the third day there is a honey-yellow mass on the surface of the medium. Growth is moderate, echinulate, raised, smooth and tapering towards the margin. There is no odour. The growth becomes lighter in colour as the culture ages. A white scum ultimately forms over the colony. Later the growth becomes more vigorous. The medium is not liquefied.

Potato agar with dextrose. Growth is slow at first but becomes abundant in a week. The natural honey-yellow colour of the organism becomes light shiny yellow in this medium, but when transferred to Bovril agar it reverts to its natural colour. The growth is butyrous in consistency. There is no odour. Diastatic action is not so marked on this medium as on potato starch agar. In stab cultures growth is slow, aerobic and echinate.

Nutrient gelatine. In stab cultures growth is crateriform and liquefaction starts in 48 hours and proceeds at a moderate rate. On the third day the liquid layer is 5 mm. deep and after 6 days 20 mm. deep. There is a cloudy scum on the surface of the solid portion of the medium. 12 to 18 days are required for the complete liquefaction of a tube containing 100 cc. of the medium.

On slant cultures the organism grows well and liquefaction is evident in 24 hours. A spherical watery droplet appears at the lowest end of the inoculation in a day. Liquefaction is rapid and filiform. As liquefaction proceeds there is a cloudy scum-like substance on the surface of the medium. A slant made with 10 cc. of the medium is completely liquefied after 4 days. The medium turns light green with age.

Bovril broth. The surface of the medium becomes cloudy on the second day and a white membranous scum is formed. The scum later sinks to the bottom and a new scum is formed on the surface. As

the cultures grow older a granular, whitish deposit is formed in the medium in regular layers if undisturbed. The medium turns light green with age.

Fermentation. In fermentation tubes containing Uschinsky's modified solution plus 2 per cent. Witte's peptone and two per cent. cane sugar, the culture becomes cludy in the open arm of the tube, but remains clear in the closed arm. The tubes become more cludy as the cultures grow old. Similar results are obtained when maltose and lactose are substituted for cane sugar. The organism grows in the open arm of the tube only. This indicates its aerobic nature. No gas is formed in any culture medium.

DIASTATIC ACTION

Nutrient starch jelly stabs. There is a slight clouding on the surface of this medium on the third day, but gradually the cloudy mass sinks until it reaches the surface of the starch layer leaving a membranous coating on the surface of the medium. Tests with saturated solution of iodine in 50 per cent. alcohol show that the starch completely disappears after 15 days.

On slants the behaviour is similar, but the starch disappears completely in 10 days. Here the white cloudy sediment is more marked.

Potato starch agar. This medium is made by adding 500 cc. of Duggar's standard nutrient solution to 15 grams of starch and 10 grams of agar. On stab cultures growth is poorer than in nutrient starch jelly. There is no odour and no liquefaction. Tests with iodine produce a reddish brown colour on the surface of the medium on the 3rd day.

On slants, growth is slow, but at the point of inoculation a honey-yellow pellicle is formed. In tubes where the transfer is made as a streak the medium is covered in a week. When iodine in 50 per cent. alcohol is introduced there is no starch reaction on the surface of the medium after 12 days.

Rate of action. In order to determine the rate of diastatic action under different light conditions petri dishes poured with potato starch agar were inoculated in the centre and placed in total darkness, in diffused light, and in full light near a window. As the colonies increased in diameter the medium surrounding the colony became hyaline contrasting sharply with the dull white colour of the unaffected medium. Tests with iodine in 50 per cent. alcohol showed that the hyaline area was free of starch while the outer unaffected medium gave the typical starch reaction. The experiments showed that diastatic action occurred most rapidly in full light and slowest in darkness. The following figures give the

diameter of the colony and of the hyaline starch free area after 3 days, under the different conditions.

	Diameter of colony.	Diameter of starch- free area.
	mm.	mm.
Full light	5	25
Diffused light	4	20
Darkness	4	18

It is probable that the rate of diastatic action is directly correlated with the rate of growth of the organism, and if, as it would appear from the diameter of the colonies, growth is more rapid in light than in darkness, then the variation in the rate of diastatic action can be explained on this assumption.

RESISTANCE TO DESICCATION

Cultures 20 days old and three days old growing in Bovril broth and maize meal agar respectively were diluted with sterile water to thrice the original volume, and drops of this suspension were allowed to dry on sterile cover glasses in sterile petri dishes. After the drops had dried tests were made at intervals by inserting the cover glasses into tubes of maize meal agar. Characteristic growth was obtained from the cover slips which had not remained dry for more than 3 days. After that time no growth was obtained in the tubes.

INOCULATIONS

On plucked leaves. Healthy leaves were removed from plants unaffected by the disease, and washed in 0.1 per cent. solution of mercuric chloride and distilled water. They were then inoculated with the bacterium from pure culture and placed in sterile glass boxes containing a little distilled water. Where inoculations were made through wounds the leaves were pricked with a sterile needle before inoculation. The results of these inoculations are given in Table 1.

Only two successful inoculations were obtained. These occurred when the leaves were inoculated through wounds on the under surface and when a young culture was used for the purpose. Leaves wounded on the undersurface but inoculated with a culture 10 days old did not produce any symptoms of the disease. Experiments carried out on leaves *in situ* showed that the age of the culture was an important factor in obtaining positive results from inoculations.

On living leaves *in situ*. Before inoculation the leaves were washed with 0.1 per cent. solution of mercuric chloride and with distilled water. Wounds, where required, were made with a sterile needle. When plants growing in pots in the plant-house were used for experiment, they were placed in a damp chamber for 24 hours after inoculation.

Inoculations were made in two ways. In some experiments the bacteria were transferred direct from the culture and smeared over areas of the leaf. In others, a suspension of the bacteria was made in sterile water and sprayed on to the leaves by means of an atomiser.

The results of these inoculations are given in Table II. Where positive results were obtained the first symptom to appear was a water-soaked appearance at the point of infection on the lower surface of the leaf. Later, these areas became black and rotten and exhibited all the symptoms of the disease as seen in the field. In some cases the infected leaves were shed. All successful inoculations were examined for the presence of bacteria in the leaf tissues and in some cases reisolations were made. In every case bacteria were found in abundance in the lesions; and where reisolations were made, pure cultures of the original organism were obtained. Control plants were used for all experiments. For the experiments in which the leaves were sprayed with the bacterial suspension the control leaves were sprayed with distilled water. When inoculations were made by smears the control leaves were washed and wounded. No symptoms of the disease developed on the control leaves in any experiments.

Successful inoculations were most readily obtained when the inoculum was sprayed on to the leaves as a suspension in water by means of an atomiser. All leaves, sprayed on the lower surface with a young culture, though unwounded, developed all the symptoms of the disease, and the organism was reisolated from the lesions. In some cases the disease developed most strongly at the edges of the leaf as shown in fig. 1, Plate X, while in others the disease occurred as spots fig. 2, Plate X. The position of occurrence of the disease appeared to be influenced to some extent by the angle at which the leaf hung. When the leaf was in a nearly vertical position the disease developed most rapidly at the edges whereas when the leaf was more nearly horizontal a more definite spotting occurred. Inoculations made by smearing the organism on the leaves at definite points did not prove so successful.

In the experiment carried out on 13th November, 1924, and 22nd June, 1925, only leaves which had been previously wounded developed the disease, unwounded leaves remained healthy. Unfortunately, the age of the culture used on 13th November, 1924, was not recorded.

TABLE 1
Inoculations on plucked leaves in glass boxes

<i>Date of inoculation.</i>	<i>Method of inoculation.</i>	<i>No. of inoculations</i>	<i>Sur- fac.</i>	<i>Woun- ded or un- wounded</i>	<i>Age of cul- ture.</i>	<i>Date of appearance of the dis- ease.</i>	<i>Suc- cess.</i>	<i>Remarks.</i>
11.6.24	Smear.	3	U.	W.	12	—	0	—
		3	L.	W.	12	—	0	—
22.6.25	Smear.	6	U.	Un.	10	—	0	—
		5	U.	W.	10	—	0	—
22.6.25	Smear.	6	U.	Un.	3	—	0	—
		3	U.	W.	3	27.7.25	2	Small water-soaked areas on the lower surface. Later developed typical symptoms.

U. = Upper surface. L. = Lower surface. W. = Wounded. Un. = Unwounded

TABLE II
Inoculations on leaves in situ

13.11.24	Smear.	4	U.	W.	?	25.11.25	3	Developed a dark-brown spot surrounded by a water-soaked zone. Two leaves dropped off the plant a week later.
		4	U.	Un.	?	—	0	—
		4	L.	Un.	?	—	0	—
25.5.25	Smear.	6	L.	W.	5	14.7.25	6	Water-soaked spot on the under surface.
		6	L.	Un.	5	—	0	—
27.7.25	Sprayed.	4	L.	Un.	3	20.8.25	4	Numerous typical lesions developed in two. On two others on the lower margin of the leaves.
		leaves.						
22.7.25	Sprayed.	3	L.	Un.	3	6.8.25	3	Experiment carried out on plant in the field. Symptoms developed on one half of the lamina in two cases.
		leaves.						

TABLE II—(Contd.)

Date of inoculation.	Method of inoculation.	No. of inoculations.	Sur-face.	Woun-ded or un-wounded	Age of cul-ture.	Date of appearance of the dis-ease.	Suc-cess.	Remarks.
10.9.25	Sprayed.	5 leaves.	L.	Un.	3	20.9.25	3	Two leaves developed from the margin. One all over the lamina.
28.9.25	Sprayed.	5 leaves.	L.	Un.	4	6.10.25	4	1 leaf all over the lamina, two at the margin, 1 at the tip of the leaf.

TECHNICAL DESCRIPTION

Bacterium betle Ragunathan n. sp.

Rods, cylindrical, rounded at ends, solitary or in pairs, in short chains in 20 days-old Bovril broth; cells $0.5 \times 1.5-2.5\mu$, non-motile, no spores, not capsulated, honey-yellow, shiny, viscid in mass and gram-negative.

No growth in Fermis solution; feeble growth in Cohn's and Ushinsky's solution; good growth in nutrient Bovril broth which turns light green with age.

On Bovril agar, the colonies are honey-yellow, growth good, circular at first later becoming echinulate, raised, smooth, tapering towards the margin and shiny. Growth becomes slightly whitish as the culture grows old. Liquefies 2 per cent. gelatine, growth more napiform than crateriform. Liquefies nutrient gelatine, growth filiform. Does not liquefy agar; reduces starch; colour changes in potato dextrose agar; resists drying for 3 days. The group number of this organism according to the chart of the Society of American Bacteriologists is 211:0000514.

CONTROL

Betel leaves are used for chewing and consequently the use of a poisonous spray in the control of this disease is inadvisable. The most obvious method of control is by hand-picking the diseased leaves as soon as the first symptom of infection is seen. So long as diseased leaves remain on the plant they provide abundant infectious material which may be carried by insects or by rain to other leaves. The diseased leaves have no value for market and they should be destroyed by fire whenever seen. The sooner they are destroyed the better it will be for the garden.

They should not be allowed to stand until the diseased patch is brown or black, and free bacteria are being extruded; the presence of a water-soaked area on the underside of the leaf should be sufficient indication that the leaf is attacked. The destruction by fire of leaves at this stage of infection would do much to prevent further spread of the disease through the garden.

Beyond hand-picking, no direct method of control can at present be advocated beyond attention to the general sanitation of the gardens.

SUMMARY

A bacterial leaf disease of betel is described.

The causal organism associated with this disease has been named *Bacterium betle*, and its behaviour on various media described.

Healthy leaves inoculated with this organism grown in pure culture produced typical symptoms of the disease, and the organism was successfully reisolated from these lesions.

Suggestions are made for the control of the disease.

Plate X.

- Fig. 1. Inoculated leaf showing marginal infection. Viewed from the upper surface. $\times \frac{2}{3}$.
 „ 2. Inoculated leaf showing infection at definite spots. Viewed from the under surface. $\times \frac{2}{3}$.

Plate XI.

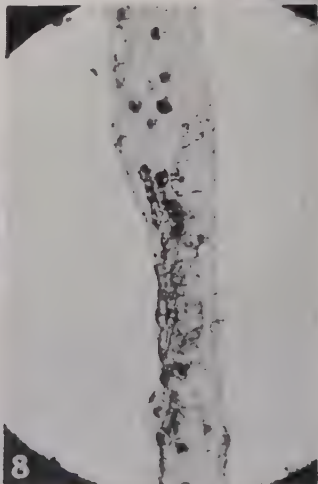
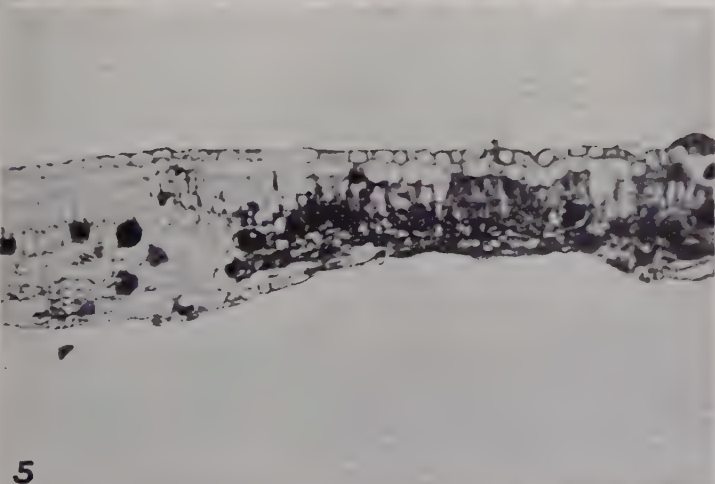
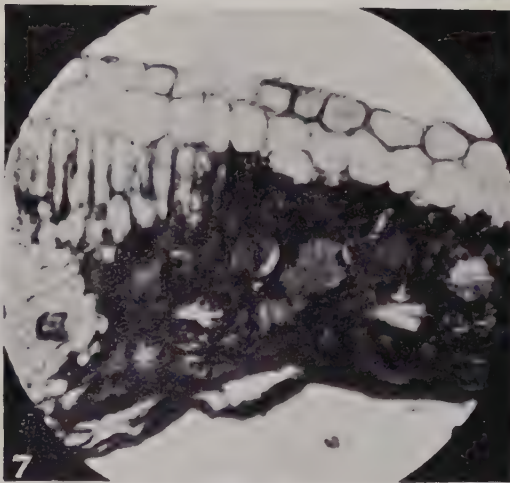
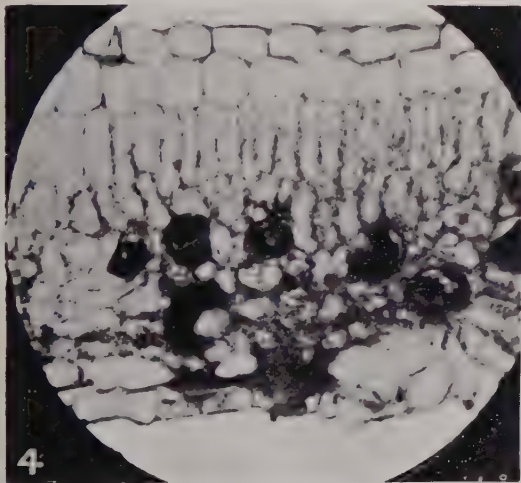
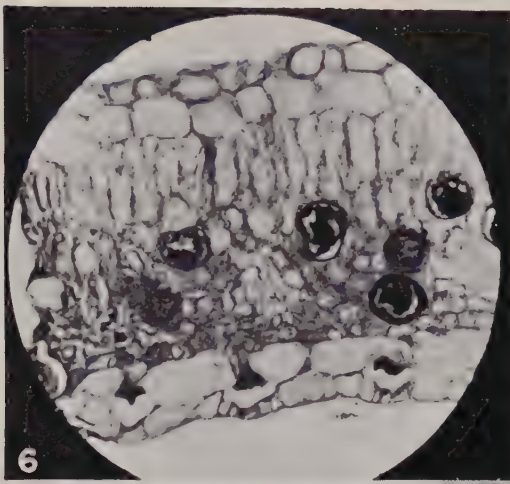
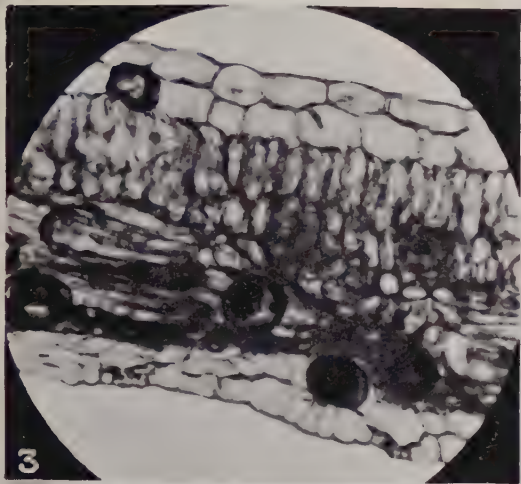
- „ 3. Transverse section, healthy betel leaf, stained with Loeffler's alkaline methylene blue. $\times 138$.
 „ 4. Transverse section through infected leaf showing invasion of bacteria into the mesophyll. Stained with Loeffler's alkaline methylene blue. $\times 138$.
 „ 5. An enlarged photo of fig. 8. $\times 67$.
 „ 6. Transverse section of infected leaf showing the bacterial masses in the sub-stomatal cavities. Stained with Loeffler's alkaline methylene blue. $\times 138$.
 „ 7. Transverse section of infected leaf in advanced stage. Stained with Ziehl's carbol fuchsin. $\times 165$.
 „ 8. Transverse section of infected leaf. Stained with Loeffler's alkaline methylene blue. $\times 30$.



2

Bacterial Leaf Spot of Betel.

1



Bacterial Leaf Spot of Betel.

Report on a Bark Examination of Peradeniya and Heneratgoda Rubber Trees

BY

J. C. Haigh, B.Sc., A.R.C.S., A.I.C.T.A.

Assistant Mycologist, Department of Agriculture, Ceylon

WITH FOUR PLATES

The first essential in an attempt to improve yield in rubber on a large scale is to select trees of a known high yield for propagation by seed or budwood. On estates where yield records of the more productive trees have been kept for a considerable period, selection is an easy matter. Where individual yields are not available, however, or where the yield potentiality of trees which are only just coming into tapping is desired, estimation of actual yield is likely to be a long process. At least three years' records are required to give a reasonable estimate of the yield of a tree.

In these circumstances a quicker method is desirable. The method is to hand; it takes the form of a latex-vessel row count. Bryce and Gadd (1) and Taylor (3) have shown that there exists a correlation between yield and the number of rows of latex vessels present in the bark of the tree. The correlation is only weak, it is true, but it is stronger than the relationship existing between yield and any other single vegetative character so far examined, and it is considered to be sufficiently reliable to indicate trees of high promise.

Examination by the counting method of all untapped trees at Peradeniya and Heneratgoda has been undertaken at the request of the Director of Agriculture, and the results of the examination are embodied in this report. In all, 2346 trees were examined, 1766 at the Experiment Station, Peradeniya, 552 at the Botanic Gardens, Heneratgoda, and 28 at the Botanic Gardens, Peradeniya.

If Taylor's figure of 30 latex-vessel rows and a bark thickness of 8 millimetres is taken as a criterion of suitability of a mother tree, it must be concluded that few trees in these stations reach the necessary standard. Out of all the trees sampled, only 37 fulfil the required conditions, and

only 55 have 28 or more rows of latex vessels. The location of these trees will be found in Table V (p. 70), at the end of this report.

The bark samples were taken by means of a metal punch, and were kept in spirit until examined. A "sample" includes the whole of the bark down to and including the cambium. The number of the tree from which the sample was taken was written in lead pencil on the outside of the plug of bark. This marking was found to be unaffected by the spirit. For examination, the samples were cut in half in a direction parallel to the "grain" on the inside of the plug, whereby a longitudinal section was obtained (Taylor and Holland, 4). Care was taken that the section was exactly longitudinal, and that the cut surface was plane. The half-plugs were placed in Eau de Javelle for half an hour, and then washed in several changes of water for some hours. They were examined under a dissecting microscope, the latex vessels being easily distinguishable as parallel white lines running across the cut surface.

A second method which is due to Major Gough (2) was tried. The method was as follows. A thin section of bark was cut and immersed for $1\frac{1}{2}$ minutes in pure nitric acid containing a saturated solution of chlorate of potash. The remains of the fragment were removed with a splinter of wood and washed in fresh water. They were then put into a solution of caustic potash for two or three minutes, at the end of which time the glass dish containing the shaving (still immersed in caustic potash) was placed on the stage of a dissecting microscope. The latex vessels, standing out as white lines against a dark background, could then be counted with ease. This method is an excellent one when only a few counts are to be made; the latex rows stand out more prominently than in the Eau de Javelle method. There is, however, a strong tendency for the sections to disintegrate, which necessitates very careful handling. On the whole, the Eau de Javelle method was found to be both quicker and more convenient in the examination of a large number of trees.

Original bark only was sampled, and three samples were taken from each tree, all at the same height. In order to make the results comparable, the plugs were taken at three feet wherever possible, but in some of the Heneratgoda trees it was found necessary to go higher than three feet to find original bark. It was considered advisable to take three samples per tree in order to obtain a fair mean, and experience has fully justified the precaution. Variation in all ways has been found sufficiently great to eliminate almost entirely the personal error, and it is necessary to consider a few of these variations.

There is, in many cases, an appreciable variation in the thickness of the three plugs from a single tree. It is unnecessary to go into great detail, but one or two cases may be given. In the Experiment Station

Peradeniya, Plot 83 B, No. 10, the three plugs had thicknesses of 15, 12 and 9 millimetres respectively (or 1.7 : 1.3 : 1.0). In Heneratgoda Plot II, No. 92, the plugs were 10, 10 and 5 millimetres (or 2 : 2 : 1) in thickness, and in Plot II, No. 140, they were 16, 15 and 6 millimetres (or 2.7 : 2.5 : 1.0) respectively. In many cases, difference in bark thickness has no effect on the number of latex-vessel rows. In the thinner sections, the rows are more closely arranged, as, for example, 83 B, No. 10, quoted above, where the three plugs of thickness 15, 12 and 9 millimetres had 22, 22, 19 rows respectively. This, however, is by no means the general rule. Heneratgoda Plot II, No. 140, quoted above, had samples of 16 millimetres with 33 rows, 15 millimetres with 32 rows, and 6 millimetres with 11 rows, while No. 92 in the same plot had samples 10 millimetres with 28 rows, 10 millimetres with 28 rows, and 5 millimetres with 17 rows respectively. The famous Heneratgoda No. 2 gave samples of 22 millimetres with 63 rows, 20 millimetres with 60 rows, and 17 millimetres with 41 rows. Many more examples can be given, but these will suffice to show that from the point of view of bark thickness alone it is essential to take several samples.

In bark of uniform thickness, there are also differences of arrangement of latex vessels in different parts of the same tree. Here, again, a few examples will suffice. In Experiment Station, Peradeniya, Plots 151-154, No. 398, the three plugs were of the same thickness, but, whereas in each of two of them the inner 2 millimetres had 12 rows, in the third sample the same area contained no rows whatever. Another case (Heneratgoda, Plot II, 246) gave samples of equal thickness, with counts of 28, 17 and 16 respectively. Numerous other examples can be given, but it is unnecessary. It may be objected that these are exceptional cases which can be ignored, but they are exceptional only in that they are extreme examples. The number of cases in which the variation is sufficiently great to be due to something other than the personal factor is too large to allow of their being ignored.

It is customary to speak of three "types" of arrangement of latex-vessel rows, the closely arranged, the widely spaced, and the grouped, but it would seem from observations made that no hard and fast rule can be drawn. The so-called types overlap, and differences are found even in the same tree. This is particularly true of older trees. In Experiment Station, Peradeniya, 151-154, 401, the three samples had 32, 21 and 20 rows respectively. The 32-row sample differed from the others in its greater thickness and in having its rows massed together at points where the other two samples showed only single rows. In Experiment Station, Peradeniya, Hillside, 9, a sample 7 millimetres in thickness had 11 rows closely arranged, whereas a second sample, 3 millimetres thick, had 5

rows widely spaced. It is to be noted that the wide spacing occurred in the thinner plug. In many old trees, a group of closely-arranged rows is found commonly about the middle of the plug. The presence of the group in some cases and of only a single row in others suggests an intermediate form between the wide spacing and either the close or the grouped, according as all or only scattered rows are replaced by groups. These variations seem to make it essential that several samples (and not less than three) should be taken at each height, if a true estimate of the structure of the bark is to be obtained.

Since no records exist of the yields of the trees under examination, it is impossible to obtain any data for calculating the degree of correlation between yield and number of latex-vessel rows, nor would such calculations be within the scope of the present report. At the same time, a short discussion of some of the causes of the comparatively weak correlation between yield and latex rows is not out of place.

It has been pointed out by Taylor (3, p. 23) that "yield does not, however, wholly depend on the number of rows in the cortex. On tapping, the innermost millimetre, or millimetre and a half, of the cortex, is not drawn upon for the yield collected. It can easily be seen that one whole series of rows may be left untapped and this would naturally have a very great effect on the amount of latex produced, especially if the tree had only about twelve to eighteen rows altogether."

When it is remembered that the "millimetre, or millimetre and a half" left untapped is a very variable amount (for no tapper, however skilled, can hope always to stop within a fixed distance of the cambium, and even very slight variations of the order of 0.5 millimetres or less become significant when there may be three rows to a millimetre of bark) and also that arrangement and structure vary widely, it may be wondered why there should be any correlation at all between yield and latex rows. It is therefore of interest to examine the proportion of rows reached by the tapper in a collection of trees taken at random, assuming for present purposes that a fixed amount of bark (say 1/16", or 1.6 millimetres) is always left untapped. In this connection, the writer has been privileged to see a collection of photographs of bark sections of trees on Govinna Estate made by Mr. H. W. Roy Bertrand. These sections were taken at a uniform height of three feet and are therefore comparable; as the trees are of no particular condition or parentage, the sections should give information which might be expected from any random group of trees.

The sections are photographed all at $\times 10$ magnification, so that it is an easy matter to count, by using a strip of card $\frac{5}{8}$ " ($=10 \times 1/16$ ") in width, the number of rows in the innermost 1/16" of bark (for our purpose, the part left untapped) and so to calculate the number of rows

tappable and untouched in any section. The results of 548 counts are recorded in the frequency array below and also as a frequency polygon in Text fig. 1.

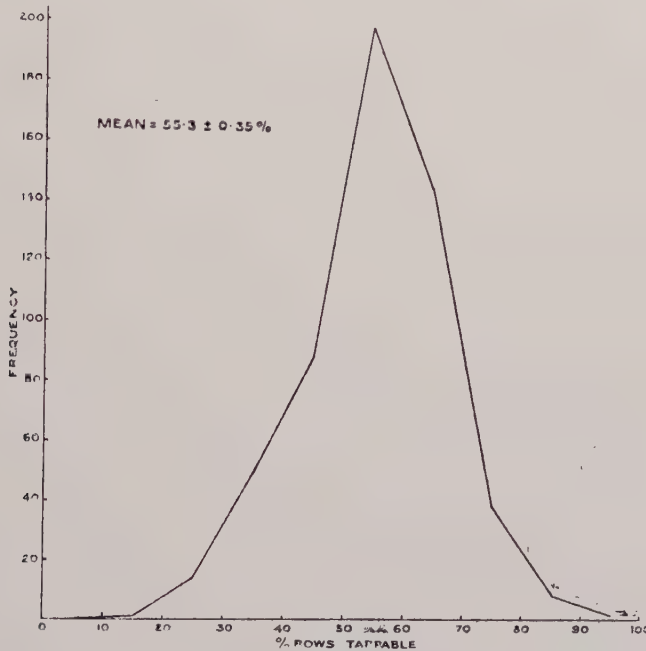


Fig. 1.—Frequency Polygon of percentage latex-vessel rows reached by tapper.

TABLE I

Frequency array of percentage tappable rows in 548 trees of Govinna Estate

Percentage tappable rows.	Frequency.
0—10	—
10—20	1
20—30	14
30—40	49
40—50	88
50—60	198
60—70	144
70—80	38
80—90	8
90—100	1
	541
No rows tappable	7
	548

Mean = 55.3 ± 0.35%

σ = 12.6%

In 7 trees no rows were touched ; the other 541 give a polygon which approaches very closely to the normal curve. This is all the more significant when we consider the frequency array of the total latex-vessel rows for the trees under examination (Table II below).

TABLE II

Frequency array of total latex-vessel rows of 548 trees from
Govinna Estate

<i>No. of rows.</i>					<i>Frequency.</i>
3	..	..	..	..	1
4	..	..	..	..	4
5	..	..	..	..	1
6	..	..	..	..	5
7	..	..	..	..	16
8	..	..	..	..	22
9	..	..	..	..	29
10	..	..	..	..	47
11	..	..	..	..	50
12	..	..	..	..	49
13	..	..	..	..	49
14	..	..	..	..	39
15	..	..	..	..	30
16	..	..	..	..	43
17	..	..	..	..	21
18	..	..	..	..	29
19	..	..	..	..	25
20	..	..	..	..	21
21	..	..	..	..	17
22	..	..	..	..	11
23	..	..	..	..	9
24	..	..	..	..	3
25	..	..	..	..	9
26	..	..	..	..	2
27	..	..	..	..	—
28	..	..	..	..	3
29	..	..	..	..	2
30	..	..	..	..	6
31	..	..	..	..	1
32	..	..	..	..	2
33	..	..	..	..	—
34	..	..	..	..	1
35	..	..	..	..	—
36	..	..	..	..	—
37	..	..	..	..	—
38	..	..	..	..	—
39	..	..	..	..	—
40	..	..	..	..	1
					548

$$\text{Mean} = 14.51 \pm 0.152$$

$$\sigma = 5.28$$

That these trees do not form a uniform group is indicated by the irregular nature of the frequency polygon (Text fig. 2), and that a

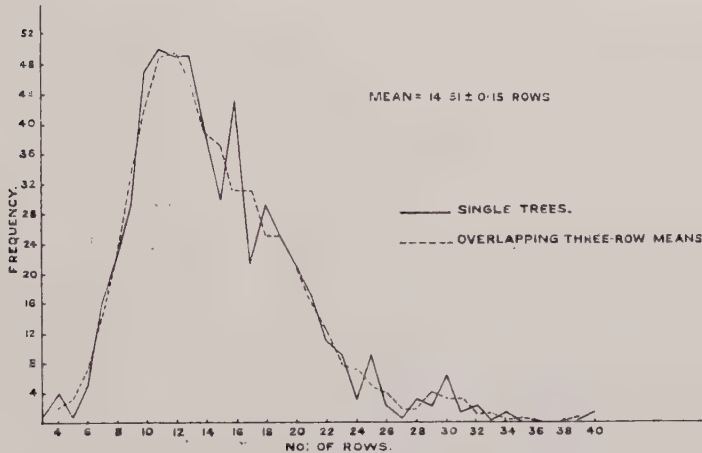


Fig. 2.—Frequency Polygon of latex-vessel rows of 548 trees on Govinna Estate.

heterogeneous collection of trees should give a result as regular as that obtained emphasises the non-dependence of percentage tappable rows on total latex-vessel rows and on their arrangement in the bark. Between the limits 40-70 % are to be found 430 readings, or 79.5% of the whole. It would seem, then, that the arrangement of the rows within the bark is not responsible for the discrepancy between yield and latex-vessel rows, even when it is remembered that the above calculation assumes a fixed amount ($1/16''$ or 1.6 millimetre) of untapped bark.

The photographs referred to above are even more illuminating in that they indicate the presence of unproductive vessels. In his examination of rubber bark, Mr. Bertrand found that, on staining his sections with acetic sudan III (the presence of 50% acetic acid was found to clear the section and to prevent plasmolysis), some vessels were stained a brick-red whereas the majority stained a brilliant shade of red. The former were found to be unproductive vessels by testing with carbon bisulphide or petrol. After immersion for a few hours the contents of the useless vessels were undissolved, whereas the contents of normal vessels went into solution.

By marking the number and position of these unproductive vessels on the photographs, it is possible to study their distribution, and counts

have been made of the proportion of such vessels occurring in the tappable bark. The results are given below (Table III):—

TABLE III

Occurrence of unproductive vessels

(1) Trees counted	..	364
(2) Number without unproductive vessels in tappable bark	..	175 or 48.1%
(3) Number with unproductive vessels in tappable bark	..	189 or 51.9%
(4) Number of (3) with 100% unproductive vessels in tappable bark	..	49
(5) Number of (3) with other than 100% unproductive vessels in tappable bark	..	140

Percentage of unproductive
vessels.

Frequency.

1—10	..	..	..	4
10—20	..	..	..	12
20—30	..	..	..	23
30—40	..	..	..	14
40—50	..	..	..	19
50—60	..	..	..	19
60—70	..	..	..	14
70—80	..	..	..	15
80—90	..	..	..	19
90—100	..	..	..	1

140

Mean = $49.36 \pm 1.44\%$
 $\sigma = 23.75\%$

These results are different from those obtained with percentage tappable rows. The frequency polygon (Text fig. 3) is irregular,

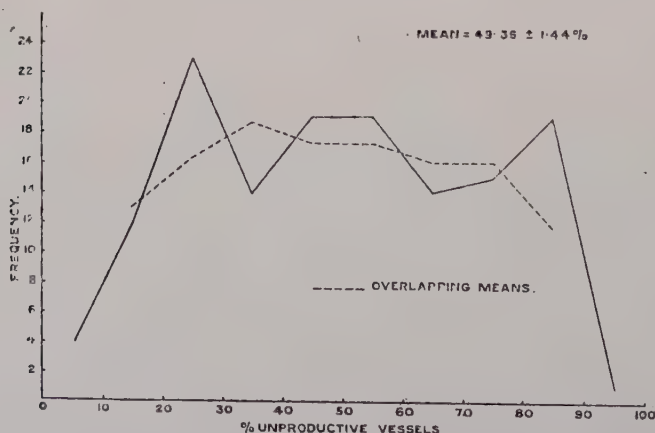


Fig. 3.—Frequency Polygon of unproductive vessels, expressed as a percentage of tappable vessels.

and overlapping means, taken with the object of smoothing the curve, give a polygon which approximates to a horizontal line and so indicates a scattered distribution. In other words, the proportion of unproductive vessels is by no means uniform and is haphazard in occurrence. Now, in an unstained section there is nothing to distinguish the good latex vessels from the bad and all are counted, whereas in an estimation of yield the unproductive vessels are yielding nothing. Here, then, may be one of the causes of the weakness of the correlation between yield and latex rows.

Bryce and Gadd (1) found that an important relationship existed between number of latex-vessel rows and age. The mean number of latex-vessel rows in the plot under examination rose from 11.3 to 19.7 in two years. The present examination includes trees varying in age from 10 to 51 years, and, while it is impossible to base any arguments on the figures, there is certainly a general tendency for the mean to increase with the age of the plot as will be seen by the following table (Table IV). Strictly, of course, these figures are not comparable, since no account is taken of the varied parentage of the different groups of trees. A further objection is introduced in the fact that all these plots were not tapped at the same height.

TABLE IV

Age and No. of latex-vessel rows

<i>Age of Plot.</i>		<i>Mean number of latex-vessel rows per tree.</i>	
51 years	..	..	22.61
40	..	..	17.13
40	..	..	21.66
30	..	..	19.91
22	..	..	17.65
19	..	..	14.04
17	..	..	15.00
17	..	..	13.76
14	..	..	16.74
14	..	..	14.47
14	..	..	13.38
14	..	..	11.94
14	..	..	11.34
10	..	..	9.23

The best trees found are given in the table below (Table V).

TABLE V

Summary of best trees from latex-vessel row count

A.—Trees with more than 30 latex-vessel rows.

Experiment Station, Peradeniya.

<i>Plot.</i>		<i>Tree.</i>		<i>Mean No. of rows.</i>
151—154	..	47	..	33.0
		98	..	30.3
85 A	..	16	..	36.7
78 A	..	36	..	32.3
		45	..	32.0
78 B	..	37	..	33.3
79 C	..	46	..	32.7
80 C	..	39	..	33.0
81 B	..	42	..	30.3
		46	..	44.7
82 C	..	39	..	32.0

Heneratgoda Gardens.

I	..	2	..	54.7
		7	..	31.3
		8	..	32.0
		18	..	32.0
II	..	86	..	39.7
		88	..	36.0
		111	..	34.7
		203	..	42.0
		221	..	30.0
III	..	349	..	31.7
		355	..	31.0
Riverside	..	371	..	31.7
		383	..	37.3
		397	..	30.3
		400	..	41.0
		401	..	32.3
		407	..	33.0
		411	..	32.0
		439	..	39.0
		440	..	32.7
		444	..	30.3
		464	..	31.3
IV	..	71	..	37.0

Botanic Gardens, Peradeniya.

14	..	32.7
24	..	30.0
26	..	31.3

*B. Trees with 28 to 30 latex-vessel rows.**Experiment Station, Peradeniya.*

<i>Plot.</i>		<i>Tree.</i>		<i>Mean No. of rows.</i>
151-154	..	3	..	28.0
		90	..	28.3
		104	..	29.0
		246	..	29.7
78 A & B	..	13	..	29.0
Extra.				

Heneratgoda Gardens.

I	..	3	..	29.3
		6	..	29.3
II	..	124	..	28.3
		385	..	29.0
Riverside	..	428	..	29.7
		437	..	29.7
		441	..	29.7
		445	..	28.7
		463	..	29.7
		72	..	28.0
IV	..			

Botanic Gardens, Peradeniya.

1	..	29.0
4	..	29.7
18	..	28.3

In conclusion, I would wish to thank Mr. H. W. Roy Bertrand, for the loan of photographs, and Mr. Angammana, Agricultural Apprentice and temporarily my assistant, who had the laborious task of taking and preparing the samples for examination.

SUMMARY

- (1) Counts have been made of the latex-vessel rows of 2,346 trees from Peradeniya and Heneratgoda.
- (2) Of these trees, 37 have more than 30 latex-vessel rows, and are considered to be suitable as mother trees.
- (3) A short discussion of some possible causes of weakness of correlation between yield and latex-vessel rows is appended.

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APPENDIX—SUMMARY OF PLOTS EXAMINED

Experiment Station, Peradeniya

Block I

Plots 68 to 76—(Avenue Rubber).

Planted in June, 1913, with stumps grown from seed from old trees in the Royal Botanic Gardens, Peradeniya. Age now 14 years.

<i>No. of rows.</i>	<i>Frequency.</i>	
6.5—7.5	1	
7.5—8.5	7	
8.5—9.5	10	
9.5—10.5	12	
10.5—11.5	11	
11.5—12.5	14	
12.5—13.5	10	
13.5—14.5	10	
14.5—15.5	12	
15.5—16.5	4	Mean = 13.38 ± 0.26 .
16.5—17.5	5	
17.5—18.5	4	$\sigma = 3.99$
18.5—19.5	4	
19.5—20.5	2	at 3 feet
20.5—21.5	1	
21.5—22.5	2	
22.5—23.5	2	
23.5—24.5	—	
24.5—25.5	1	
25.5—26.5	—	
26.5—27.5	1	
	113	

A small group, distribution somewhat scattered, but fairly uniform. No outstanding trees. Frequency polygon, Plate XII, fig. 1.

Plot 77. Trees all under tapping.

Plots 78-86. Planted April, 1905. Age now 22 years.

<i>No. of rows.</i>	<i>Frequency.</i>	
7.5—8.5	1	
8.5—9.5	—	
9.5—10.5	3	
10.5—11.5	10	
11.5—12.5	13	
12.5—13.5	11	
13.5—14.5	26	
14.5—15.5	28	
15.5—16.5	31	
16.5—17.5	26	
17.5—18.5	16	
18.5—19.5	26	Mean = 17.65 ± 0.20
19.5—20.5	16	
20.5—21.5	14	$\sigma = 4.86$
21.5—22.5	10	
22.5—23.5	9	at 3 feet.
23.5—24.5	7	
24.5—25.5	2	
25.5—26.5	3	

<i>No. of rows.</i>	<i>Frequency.</i>
26.5—27.5	—
27.5—28.5	—
28.5—29.5	1
29.5—30.5	1
30.5—31.5	—
31.5—32.5	3
32.5—33.5	3
33.5—34.5	—
34.5—35.5	—
35.5—36.5	—
36.5—37.5	1
37.5—38.5	—
38.5—39.5	—
39.5—40.5	—
40.5—41.5	—
41.5—42.5	—
42.5—43.5	—
43.5—44.5	—
44.5—45.5	1
262	

A fairly uniform group, with scattered trees of good value. Frequency polygon Plate XIV, fig. 2

Plot 87. All under tapping.

Block II. Trees not numbered—age only 7 years.

Block III. Under tapping.

Block IV. Under tapping.

Block V.

Plots 151—154.

Planted with stumps from Udapolla Estate in 1908. Age now 19 years.

<i>No. of rows.</i>	<i>Frequency.</i>	
3.5—4.5	1	
4.5—5.5	1	
5.5—6.5	6	
6.5—7.5	13	
7.5—8.5	23	
8.5—9.5	31	
9.5—10.5	20	
10.5—11.5	35	
11.5—12.5	36	
12.5—13.5	30	
13.5—14.5	32	
14.5—15.5	22	
15.5—16.5	18	
16.5—17.5	20	Mean=14.04 $\pm$ 0.18
17.5—18.5	18	
18.5—19.5	17	ϕ =5.31
19.5—20.5	9	
20.5—21.5	13	at 3 feet.
21.5—22.5	9	
22.5—23.5	4	
23.5—24.5	3	
24.5—25.5	5	
25.5—26.5	3	

<i>No. of rows.</i>	<i>Frequency.</i>
26.5—27.5 ..	4
27.5—28.5 ..	2
28.5—29.5 ..	1
29.5—30.5 ..	2
30.5—31.5 ..	—
31.5—32.5 ..	—
32.5—33.5 ..	1
	389

A fairly uniform group. This group includes tapped as well as untapped trees, but the best trees are under tapping. Frequency polygon, Plate XV, fig. 3.

Block VI.

Plot 140A.

Planted in 1913 with one year old stumps of a blackseeded variety from Heneratgoda. Age now 14 years.

<i>No. of rows.</i>	<i>Frequency.</i>	
7.5—8.5 ..	1	
8.5—9.5 ..	1	
9.5—10.5 ..	—	
10.5—11.5 ..	6	
11.5—12.5 ..	4	
12.5—13.5 ..	3	
13.5—14.5 ..	4	
14.5—15.5 ..	6	
15.5—16.5 ..	3	Mean = 14.47 ± 0.40
16.5—17.5 ..	1	
17.5—18.5 ..	2	$\sigma = 3.60$
18.5—19.5 ..	3	
19.5—20.5 ..	—	at 3 feet.
20.5—21.5 ..	1	
21.5—22.5 ..	—	
22.5—23.5 ..	—	
23.5—24.5 ..	—	
24.5—25.5 ..	—	
25.5—26.5 ..	1	
	36	

A poor group The mean is fairly near that obtained for the Heneratgoda blackseeded group.

Block VII—Hilltop Rubber.

Planted in 1913 with two-year old stumps raised from seed of old trees in the Royal Botanic Gardens, Peradeniya. Age now 14 years.

<i>No. of rows.</i>	<i>Frequency.</i>	
3.5—4.5 ..	1	
4.5—5.5 ..	1	
5.5—6.5 ..	8	
6.5—7.5 ..	17	
7.5—8.5 ..	42	
8.5—9.5 ..	37	
9.5—10.5 ..	58	
10.5—11.5 ..	49	Mean = 11.34 ± 0.10
11.5—12.5 ..	47	
12.5—13.5 ..	30	$\sigma = 2.91$
13.5—14.5 ..	28	
14.5—15.5 ..	11	at 3 feet.

<i>No. of rows.</i>	<i>Frequency.</i>
15.5—16.5 ..	5
16.5—17.5 ..	5
17.5—18.5 ..	5
18.5—19.5 ..	1
19.5—20.5 ..	2
20.5—21.5 ..	—
21.5—22.5 ..	1
22.5—23.5 ..	—
23.5—24.5 ..	—
	391

A very uniform group, but of poor quality. Frequency polygon, Plate XIII, fig. 2.

Block VIII—Hillside Rubber.

Planted in 1913 from two-year old stumps raised from seed of old trees in the Royal Botanic Gardens, Peradeniya. Age now 14 years.

<i>No. of rows.</i>	<i>Frequency.</i>	
4.5— 5.5 ..	1	
5.5— 6.5 ..	3	
6.5— 7.5 ..	6	
7.5— 8.5 ..	19	
8.5— 9.5 ..	27	Mean = 11.94 ± 0.14
9.5—10.5 ..	25	
10.5—11.5 ..	43	
11.5—12.5 ..	28	$\sigma = 3.31$
12.5—13.5 ..	24	
13.5—14.5 ..	17	at 3 feet.
14.5—15.5 ..	23	
15.5—16.5 ..	12	
16.5—17.5 ..	8	
17.5—18.5 ..	4	
18.5—19.5 ..	3	
19.5—20.5 ..	1	
20.5—21.5 ..	1	
21.5—22.5 ..	—	
22.5—23.5 ..	—	
23.5—24.5 ..	1	
	246	

Uniform, but of poor quality. Frequency polygon, Plate XII, fig. 2.

Bandaratenne Rubber.

Planted June, 1917, with one year old stumps from Botanic Gardens. Age 10 years.

<i>No. of rows.</i>	<i>Frequency.</i>
2.5— 3.5 ..	3
3.5— 4.5 ..	3
4.5— 5.5 ..	15
5.5— 6.5 ..	29
6.5— 7.5 ..	37
7.5— 8.5 ..	52
8.5— 9.5 ..	50
9.5—10.5 ..	39

<i>No. of rows.</i>		<i>Frequency.</i>	
10.5—11.5	..	37	Mean = 9.25 ± 0.10
11.5—12.5	..	24	
12.5—13.5	..	16	$\sigma = 3.70$
13.5—14.5	..	12	
14.5—15.5	..	8	at 3 feet.
15.5—16.5	..	2	
16.5—17.5	..	1	
17.5—18.5	..	1	
		329	

This is the most uniform of all the groups. It is poor in quality, but is young.
Frequency polygon, Plate XIII, fig. 1.

Heneratgoda Gardens

Plot I—Planted 1876 with seed from Kew.

<i>No. of rows.</i>		<i>Frequency.</i>	
9.5—10.5	..	1	
10.5—11.5	..	—	
11.5—12.5	..	2	
12.5—13.5	..	1	
13.5—14.5	..	—	
14.5—15.5	..	2	
15.5—16.5	..	1	
16.5—17.5	..	1	Mean = 22.61 ± 0.89
17.5—18.5	..	3	
18.5—19.5	..	—	$\sigma = 7.91$
19.5—20.5	..	3	
20.5—21.5	..	4	
21.5—22.5	..	—	at 3 feet.
22.5—23.5	..	3	
23.5—24.5	..	3	
24.5—25.5	..	1	
25.5—26.5	..	3	
26.5—27.5	..	2	
27.5—28.5	..	—	
28.5—29.5	..	2	
29.5—30.5	..	—	
30.5—31.5	..	1	
31.5—32.5	..	2	
— —	..	—	
— —	..	—	
— —	..	—	
54.5—55.5	..	1	
		36	

A heterogeneous group, with one outstanding tree (No. 2).

Plots II and III—Planted 1887.

<i>No. of rows.</i>		<i>Frequency.</i>
5.5— 6.5	..	2
6.5— 7.5	..	1
7.5— 8.5	..	6
8.5— 9.5	..	4
9.5—10.5	..	9
10.5—11.5	..	11
11.5—12.5	..	7

<i>No. of rows.</i>		<i>Frequency.</i>	
12.5—13.5	..	17	
13.5—14.5	..	16	
14.5—15.5	..	23	
15.5—16.5	..	19	
16.5—17.5	..	18	
17.5—18.5	..	16	
18.5—19.5	..	9	
19.5—20.5	..	13	
20.5—21.5	..	8	
21.5—22.5	..	7	Mean=17.13±0.26
22.5—23.5	..	12	
23.5—24.5	..	7	♂=5.72
24.5—25.5	..	4	
25.5—26.5	..	2	at 7 feet.
26.5—27.5	..	1	
27.5—28.5	..	4	
28.5—29.5	..	—	
29.5—30.5	..	1	
30.5—31.5	..	1	
31.5—32.5	..	1	
32.5—33.5	..	—	
33.5—34.5	..	—	
34.5—35.5	..	1	
35.5—36.5	..	1	
36.5—37.5	..	—	
37.5—38.5	..	—	
38.5—39.5	..	—	
39.5—40.5	..	1	
40.5—41.5	..	—	
41.5—42.5	..	1	
		223	

A moderately uniform group, with a few good trees. Frequency polygon, Plate XV, fig. 1.

Riverside—Planted 1887.

<i>No. of rows.</i>		<i>Frequency.</i>	
10.5—11.5	..	1	
11.5—12.5	..	2	
12.5—13.5	..	3	
13.5—14.5	..	1	
14.5—15.5	..	10	
15.5—16.5	..	4	
16.5—17.5	..	6	
17.5—18.5	..	5	
18.5—19.5	..	6	
19.5—20.5	..	11	
20.5—21.5	..	2	
21.5—22.5	..	2	
22.5—23.5	..	7	
23.5—24.5	..	4	
24.5—25.5	..	2	Mean=21.66±0.46
25.5—26.5	..	3	
26.5—27.5	..	3	♂=6.43
27.5—28.5	..	—	
28.5—29.5	..	2	at 4 feet.
29.5—30.5	..	6	
30.5—31.5	..	1	
31.5—32.5	..	3	

<i>No. of rows.</i>	<i>Frequency</i>
32.5—33.5 ..	2
33.5—34.5 ..	—
34.5—35.5 ..	—
35.5—36.5 ..	—
36.5—37.5 ..	1
37.5—38.5 ..	—
38.5—39.5 ..	1
39.5—40.5 ..	—
40.5—41.5 ..	1
	89

A scattered group, with a few good trees. Frequency polygon, Plate XIV fig. 1.

Plot IV—Planted 1897.

<i>No. of rows.</i>	<i>Frequency.</i>	
9.5—10.5 ..	1	
10.5—11.5 ..	—	
11.5—12.5 ..	1	
12.5—13.5 ..	2	
13.5—14.5 ..	2	
14.5—15.5 ..	2	
15.5—16.5 ..	1	
16.5—17.5 ..	—	Mean = 19.91 ± 0.62
17.5—18.5 ..	6	
18.5—19.5 ..	2	$\phi = 5.34$
19.5—20.5 ..	1	
20.5—21.5 ..	4	at 7 feet.
21.5—22.5 ..	1	
22.5—23.5 ..	2	
23.5—24.5 ..	1	
24.5—25.5 ..	4	
25.5—26.5 ..	2	
26.5—27.5 ..	—	
27.5—28.5 ..	1	
28.5—29.5 ..	—	
29.5—30.5 ..	—	
30.5—31.5 ..	—	
31.5—32.5 ..	—	
32.5—33.5 ..	—	
33.5—34.5 ..	—	
34.5—35.5 ..	—	
35.5—36.5 ..	—	
36.5—37.5 ..	1	
	34	

A poor group, with one good tree.

Plot V—Planted 1910.

<i>No. of rows.</i>	<i>Frequency.</i>	
8.5—9.5 ..	1	
9.5—10.5 ..	5	
10.5—11.5 ..	7	
11.5—12.5 ..	6	Mean = 13.76 ± 0.25
12.5—13.5 ..	1	
13.5—14.5 ..	6	$\phi = 2.56$
14.5—15.5 ..	11	
15.5—16.5 ..	5	at 3 feet.

<i>No. of rows.</i>	<i>Frequency.</i>
16.5—17.5 ..	3
17.5—18.5 ..	3
18.5—19.5 ..	1
	49

Poor.

Progeny No. 2—Planted 1913.

<i>No. of rows</i>	<i>Frequency</i>	
7.5— 8.5 ..	1	
8.5— 9.5 ..	2	
9.5—10.5 ..	2	
10.5—11.5 ..	5	
11.5—12.5 ..	6	
12.5—13.5 ..	7	Mean = 16.74 ± 0.32
13.5—14.5 ..	5	
14.5—15.5 ..	8	$\sigma = 4.58$
15.5—16.5 ..	13	
16.5—17.5 ..	10	at 3 feet.
17.5—18.5 ..	8	
18.5—19.5 ..	5	
19.5—20.5 ..	4	
20.5—21.5 ..	3	
21.5—22.5 ..	1	
22.5—23.5 ..	—	
23.5—24.5 ..	3	
24.5—25.5 ..	6	
25.5—26.5 ..	1	
26.5—27.5 ..	1	
27.5—28.5 ..	—	
28.5—29.5 ..	1	
	92	

Not particularly good, considering its parentage. Frequency polygon, Plate XV, fig. 2.

Blackseeded—Planted 1910.

<i>No. of rows.</i>	<i>Frequency.</i>	
7.5— 8.5 ..	1	
8.5— 9.5 ..	4	
9.5—10.5 ..	1	
10.5—11.5 ..	3	
11.5—12.5 ..	1	
12.5—13.5 ..	1	
13.5—14.5 ..	2	
14.5—15.5 ..	3	Mean = 15.00 ± 0.58
15.5—16.5 ..	5	
16.5—17.5 ..	—	$\sigma = 4.62$
17.5—18.5 ..	1	
18.5—19.5 ..	—	at 3 feet.
19.5—20.5 ..	1	
20.5—21.5 ..	2	
21.5—22.5 ..	3	
22.5—23.5 ..	—	
23.5—24.5 ..	1	
	29	

Too small for comment, but not particularly promising.

Botanic Gardens, Peradeniya

Trees 1-28—Planted 1876-1885.

<i>No. of rows.</i>	<i>Frequency.</i>	
18.5—19.5	..	1
19.5—20.5	..	3
20.5—21.5	..	—
21.5—22.5	..	1
22.5—23.5	..	5
23.5—24.5	..	3
24.5—25.5	..	1
25.5—26.5	..	2
26.5—27.5	..	5
27.5—28.5	..	2
28.5—29.5	..	1
29.5—30.5	..	2
30.5—31.5	..	1
31.5—32.5	..	—
32.5—33.5	..	1
		28

Mean = 25.32 ± 0.45

♂ = 3.55

at 5 feet.

A group of heterogeneous origin. Nos. 1-9 were planted by Trimen in 1881, probably from the first seeds, or cuttings of the Heneratgoda trees. Nos. 10-20 were probably from the first batch of seeds received in 1876, while Nos. 21-28 seem to have been planted at various times between 1881 and 1885, but were probably from the original consignment.

In spite of their mixed nature, they are a fairly uniform group, and of quite good quality.

INDIVIDUAL RECORDS

Experiment Station, Peradeniya	..	Plots 68— 76
Do do	..	„ 78— 83
Do do	..	„ 83— 87
Do do	..	„ 151—154
Do do	..	„ 140 A
Do do	..	Hilltop
Do do	..	Hillside
Do do	..	Bandaratenne
Heneratgoda Gardens	..	Plot I
Do do	..	„ II
Do do	..	„ III
Do do	..	Riverside
Do do	..	Plot IV
Do do	..	Progeny No. 2
Do do	..	Plot V
Do do	..	Blackseeded
Botanic Gardens, Peradeniya.		

Avenue Rubber. Plots 68—76 (Block I.)

<i>Tree.</i>	<i>Mean No. of l.v. rows.</i>	<i>Tree.</i>	<i>Mean No. of l.v. rows.</i>	<i>Tree.</i>	<i>Mean No. of l.v. rows.</i>
I A.		III A.		V B.	
4	11.0	9	23.0	1	18.7
6	16.0	13	27.0	8	11.7
12	12.0	14	13.3	9	10.7
13	8.0	15	8.7	13	12.7
14	11.7	16	8.0	14	11.3
15	13.7	17	10.3	15	9.7
17	23.0	18	11.7	17	11.3
18	15.3	22	14.0		
20	21.7			VI A.	
23	13.7	III B.		2	14.7
I B.		2	12.0	9	9.7
3	15.0	5	16.7	10	10.3
5	9.7	9	17.0	13	10.0
6	8.3	10	11.7	22	14.7
7	19.7	13	19.0	24	12.0
9	15.7	14	13.0	25	11.7
11	12.7	19	18.7		
16	18.3	20	11.0	VI B.	
18	12.0	21	15.0	2	10.0
23	11.7	24	21.7	3	14.3
II A.		IV A.		6	9.3
2	15.0	1	19.7	9	8.3
3	16.7	5	13.0	17	9.3
4	10.3	6	12.7	18	9.0
6	13.3	17	12.0	20	18.0
7	13.0	22	21.3	22	11.3
10	16.7	24	11.3	23	6.7
12	25.3	IV B.			
13	10.3	2	15.0	VII A.	
17	9.7	3	11.0	2	14.0
19	9.0	9	9.3	6	14.0
21	14.7	10	17.7	7	14.7
22	8.0	12	8.0	10	15.3
		13	14.3	13	14.7
		20	16.0	15	10.3
		25	13.3	16	10.7
II B.				21	9.3
2	11.3	V A.		22	15.0
7	17.3	9	12.0	24	15.7
8	14.0	11	12.3	25	10.0
15	9.0	12	9.7		
16	14.0	13	8.3	VII B.	
21	14.3	17	12.7	23	17.7
22	11.3	23	19.7		
23	9.3	24	12.3		

Experiment Station, Peradeniya

Block I. Plots 78—83

<i>Tree.</i>	<i>Mean No. of l.v. rows.</i>	<i>Tree.</i>	<i>Mean No. of l.v. rows.</i>	<i>Tree.</i>	<i>Mean No. of l.v. rows.</i>
78 A.		13	29.0	80 B.	
		14	16.0		
35	18.7	15	23.0	34	16.3
36	32.3	16	15.7	35	16.0
37	24.7	17	20.3	36	16.3
38	19.0	18	22.0	37	17.3
39	19.3	19	17.0	38	20.0
40	21.0	20	17.0	39	20.3
41	19.0	78 C.		40	22.3
42	19.7			41	13.0
43	14.0	3	20.7	42	18.7
44	17.7	35	20.0	43	13.0
45	32.0	36	15.7	44	10.7
46	11.7	37	23.3	80 C.	
47	17.3	38	16.3		
48	15.7	39	14.7	39	33.0
49	16.7	40	24.0	40	17.7
50	12.0	41	13.7	41	18.0
51	11.7	42	22.0	42	25.7
52	16.7	43	15.7	44	14.3
53	19.3	44	17.0	45	15.0
54	12.0	45	12.0	46	21.0
55	17.0	46	14.7	47	18.7
56	16.0	47	14.0	49	16.3
78 B.		48	11.3	50	14.3
		50	16.7	51	17.3
36	18.7	51	11.7	52	14.3
37	33.3	52	14.3	53	15.7
39	14.0	79 B.			
40	17.7				
42	13.7	35	22.0	81 A.	
43	19.7	36	25.3		
44	22.0	37	22.0	34	17.7
45	19.7	38	20.0	35	12.3
46	26.0	39	20.7	36	16.7
47	18.0	40	22.0	37	19.7
48	10.3	41	19.7	38	19.0
49	18.0	42	24.0	39	10.7
51	22.7	43	15.0	40	14.7
52	15.3	44	21.3	42	19.0
53	16.3	45	23.3	43	13.0
54	15.7	46	16.7	44	14.0
55	15.0	79 C.		45	19.0
56	18.3			46	15.3
Extra.		38	15.0	47	14.0
		39	16.7	81 B.	
2	18.7	40	16.0		
3	19.3	42	16.0	40	16.7
4	16.7	44	19.0	42	30.3
5	21.3	45	14.3	43	17.3
6	15.3	46	32.7	44	18.3
7	18.0	48	12.0	46	44.7
8	15.0	49	12.7	48	15.7
9	18.7	50	21.0	49	13.7
10	16.0	51	12.0	50	12.7
11	14.7	52	14.3	51	14.0
12	23.0	53	12.0	52	11.0

Experiment Station, Peradeniya

Block I. Plots 78—83,—(contd.)

<i>Tree.</i>	<i>Mean No. of l.v. rows.</i>	<i>Tree.</i>	<i>Mean No. of l.v. rows.</i>	<i>Tree.</i>	<i>Mean No. of l.v. rows.</i>
81 C.		41	14.7	44	14.7
34	25.7	42	15.7	45	14.3
37	13.7	43	13.0	46	20.0
38	14.3	44	7.7	49	17.7
39	15.7	45	14.3	50	16.0
40	12.7	46	15.7	51	13.0
41	21.0	47	9.7	82 C.	
42	23.0	48	10.0	39	32.0
43	11.3	49	11.3	40	16.7
44	24.0	50	15.3	41	22.3
45	17.0	51	18.7	42	14.7
47	15.0	52	14.7	43	17.3
48	14.3	82 B.		44	23.7
50	19.7	35	15.7	45	19.0
51	17.7	36	17.3	46	13.0
52	15.0	37	19.7	47	22.7
82 A.		38	21.0	48	19.7
39	18.7	39	12.7	49	15.7
40	14.7	40	22.3		
		43	14.3		

Plots 83—87

83 A.		C & D Extra.		A & B Extra.	
2	19.0	1	22.3	1	20.0
10	15.3	2	21.0	2	18.3
17	16.0	3	17.3	3	15.7
20	17.0	4	16.0	4	12.7
21	18.7	5	10.7	5	17.3
22	16.7	6	15.0	85 D.	
B.		7	12.3	7	14.3
2	19.0	8	24.0	9	12.3
8	19.0	9	16.0	20	23.3
10	20.0	10	19.0	21	22.7
11	19.3	85 A.		86 A.	
12	17.0	3	15.0	2	17.8
D.		4	18.3	5	21.0
10	15.3	6	15.0	7	24.0
19	14.3	14	14.0	9	15.3
84 A.		15	16.3	12	19.2
19	11.0	16	36.7	13	14.0
C.		85 B.		18	19.3
8	18.3	9	21.0	23	21.0
16	16.3	13	21.3	27	15.3
18	16.3			86 C.	
19	15.0			11	11.3
20	16.7			14	11.0
				18	11.7
				19	14.3
				22	24.2

Experiment Station, Peradeniya

Plots 151—154 (Block V.)

<i>Tree.</i>	<i>Mean No. of l.v. rows.</i>	<i>Tree.</i>	<i>Mean No. of l. v. rows.</i>	<i>Tree.</i>	<i>Mean No. of l. v. rows.</i>
1	20.3	60	18.0	119	26.7
2	20.0	61	17.3	120	17.7
3	28.0	62	13.0	*121	11.7
* 5	13.7	63	15.7	*122	9.3
6	17.7	64	17.7	*123	13.0
7	21.5	65	15.0	*124	8.3
* 8	13.0	*66	8.7	*125	10.7
9	18.3	*67	15.7	126	13.0
10	21.3	69	22.3	128	12.0
11	18.7	70	19.0	129	17.0
13	26.7	*71	7.0	130	15.0
14	20.7	72	11.7	131	22.7
15	21.3	73	18.3	*132	4.3
*16	14.7	*74	9.3	133	10.0
*18	18.0	*75	9.0	*134	15.0
19	21.0	*76	8.3	*135	13.0
20	15.0	*77	7.0	136	24.0
21	18.7	78	11.0	137	14.0
22	9.3	79	13.3	*138	9.0
23	23.7	80	21.0	*139	10.3
25	20.5	*82	13.3	140	15.0
*26	27.0	83	16.7	*141	10.7
*27	12.0	84	16.7	*142	9.3
29	19.0	85	18.5	*143	8.7
30	21.7	86	12.0	144	10.3
31	11.0	87	20.3	*145	16.7
*32	14.7	*88	13.3	*146	13.3
33	17.0	*89	14.0	147	18.0
*34	25.5	90	28.3	148	12.7
*35	16.0	92	26.7	*151	9.7
36	22.0	93	15.0	152	12.3
*37	14.7	94	20.0	153	25.0
*38	17.3	95	22.3	154	15.7
*39	16.0	96	12.0	*155	14.0
*40	23.0	97	17.0	*156	7.0
41	12.7	98	13.0	*157	8.3
42	21.0	*99	10.0	*158	11.7
*43	14.5	*100	10.0	159	12.3
44	8.0	*101	14.0	161	12.0
*45	21.3	*102	7.3	*162	11.3
46	25.0	*103	10.7	*163	15.3
47	33.0	104	29.0	*164	26.3
*48	9.7	*105	10.0	*165	5.0
*49	9.3	*106	11.0	*166	10.7
*50	9.0	108	13.7	167	9.5
*51	10.3	109	19.3	168	18.0
*52	12.3	110	21.0	*169	7.7
*53	12.3	111	19.7	*170	7.3
*54	12.3	112	11.3	171	9.0
55	19.7	113	16.7	172	7.7
56	17.5	115	21.0	*173	10.0
*57	16.7	*116	10.3	175	12.7
*58	18.0	*117	9.0	176	11.3
*59	10.0	*118	9.7	177	14.3

Experiment Station, Peradeniya

Plots 151—154 (Block V.—contd.)

<i>Tree.</i>	<i>Mean No. of l. v. rows.</i>	<i>Tree.</i>	<i>Mean No. of l. v. rows</i>	<i>Tree.</i>	<i>Mean No. of l. v. rows.</i>
*178	14.0	*235	9.3	292	18.3
179	15.0	236	19.0	*293	10.7
*180	6.7	*237	12.3	294	12.3
*181	10.0	*238	13.7	295	14.0
182	19.3	*239	11.3	*296	11.3
*183	16.7	*240	8.3	*297	11.7
*184	15.3	*241	14.3	*298	9.0
185	22.7	*242	8.7	299	25.7
*186	13.0	*243	9.3	300	23.0
*187	20.0	*244	9.3	301	18.7
188	14.0	*245	13.3	*302	19.3
*189	12.0	246	29.7	303	12.0
*190	12.3	247	18.7	*304	7.0
191	18.3	248	14.3	*305	6.3
192	16.7	*249	11.7	*306	15.7
*193	7.7	*250	14.7	*307	11.7
*194	7.7	252	16.3	*308	5.7
*195	10.3	*253	7.3	*309	9.0
196	15.3	*254	7.0	*310	11.0
*197	8.3	*255	8.3	*311	15.7
*199	10.0	256	13.3	*312	15.7
*200	10.0	257	12.7	*313	13.3
*201	8.3	258	26.3	*314	11.3
202	13.3	259	19.0	*315	15.0
203	11.5	*260	11.0	*316	13.0
204	19.3	261	9.3	*317	9.3
205	14.3	262	18.7	318	11.0
206	11.0	*263	12.0	319	14.7
*207	8.3	*264	15.7	320	13.7
*208	14.0	265	18.3	321	12.0
209	15.7	266	14.3	322	13.0
210	17.7	*267	14.7	*323	9.3
211	18.0	*268	9.0	*324	14.3
*213	14.3	269	10.7	325	16.3
214	18.0	*270	11.0	326	17.3
*215	8.3	*271	8.3	*327	6.0
*216	9.3	272	14.3	328	16.3
*217	7.0	*273	10.0	329	15.7
218	14.3	*275	10.0	*330	8.0
*219	11.7	*276	17.3	*331	8.3
*220	10.7	*277	8.3	*332	11.0
*221	10.3	*278	6.3	*333	9.3
*222	9.0	*279	6.7	335	22.0
223	14.0	*280	11.0	*336	14.3
224	15.7	281	13.7	337	15.7
*225	8.0	*282	10.3	*338	10.0
226	11.3	*283	19.3	*339	10.7
227	14.3	*284	17.0	*340	10.3
*228	12.3	*285	14.3	*341	11.7
229	14.0	286	21.7	*342	11.3
230	19.7	287	12.3	*343	10.3
231	13.3	288	17.0	*344	21.7
232	19.3	*289	13.3	*345	13.3
233	15.3	290	19.3	*346	11.3
*234	25.3	*291	11.0	*347	9.7

Experiment Station, Peradeniya

Plots 151—154—(contd.)

<i>Tree.</i>	<i>Mean No. of l. v. rows.</i>	<i>Tree.</i>	<i>Mean No. of l. v. rows.</i>	<i>Tree.</i>	<i>Mean No. of l. v. rows.</i>
*348	13.0	*369	9.0	391	14.6
*349	10.0	370	16.7	*392	10.0
350	24.7	371	17.0	*393	13.0
351	22.3	372	15.3	*394	11.0
352	14.0	373	10.3	*395	12.0
*353	16.3	*374	7.3	*396	10.3
*354	11.3	375	11.7	397	19.3
355	12.7	*376	8.0	398	30.3
*356	13.0	*377	12.7	399	21.7
*357	7.7	*378	12.7	*400	16.3
*358	17.7	*379	7.0	401	24.3
359	10.7	*380	11.0	402	21.3
*360	10.3	*381	8.3	*403	11.7
*361	10.7	*382	8.7	*404	16.7
*362	11.7	*383	6.3	405	11.3
*363	6.0	*384	9.3	*406	8.7
*364	20.7	*385	7.7	*407	14.7
365	14.3	387	20.7	*408	11.7
*366	11.0	*388	13.7	*409	11.7
*367	14.7	*389	11.7	*410	11.7
*368	11.7	*390	9.3		

*—Trees hitherto untapped.

Block VI. Plot 140 A.

1	15.3	13	12.0	25	11.0
2	18.3	14	15.0	26	15.3
3	10.7	15	12.0	27	14.0
4	12.0	16	15.0	28	14.3
5	12.7	17	18.7	29	12.0
6	11.0	18	18.0	30	8.3
7	14.0	19	19.0	31	16.3
8	9.0	20	18.7	32	16.3
9	11.0	21	11.0	33	13.3
10	14.7	22	17.0	34	26.3
11	14.0	23	11.0	35	21.0
12	13.0	24	14.7	36	16.3

Block VII. (Hilltop)

1	12.7	32	7.7	54	9.3
9	8.3	33	6.0	57	10.3
11	13.0	36	8.3	60	12.0
12	11.7	38	13.0	65	12.7
14	12.3	39	10.3	66	16.0
15	12.7	42	8.3	71	14.3
18	13.3	43	16.3	72	8.3
20	16.3	44	11.0	76	10.3
24	11.7	46	12.7	77	12.0
25	13.3	48	13.7	83	15.3
29	10.0	49	13.7	84	12.0
30	8.3	53	14.3	87	12.3

A 2.

Experiment Station, Peradeniya

Block VII. (Hilltop—contd.)

<i>Tree.</i>	<i>Mean No. of l. v. rows.</i>	<i>Tree.</i>	<i>Mean No. of l. v. rows.</i>	<i>Tree.</i>	<i>Mean No. of l. v. rows.</i>
88	14.7	87	9.0	218	17.7
89	13.0	88	10.0	226	7.7
90	12.0	89	9.0	230	6.7
91	10.3	90	21.7	231	12.7
95	14.0	98	12.0	234	10.0
97	9.3	102	15.7	235	13.0
99	12.7	104	9.7	241	10.3
101	14.3	105	15.3	247	16.0
102	8.0	106	13.0	251	17.7
103	10.7	110	20.0	252	10.7
104	10.3	111	13.0	254	13.0
105	12.3	112	14.3	257	16.7
106	13.3	115	12.0	260	7.3
108	7.7	117	11.0	265	8.3
109	13.3	118	13.7	267	15.3
110	9.3	120	15.3	272	10.3
111	19.3	121	9.0	275	17.3
112	17.7	125	10.0	277	
114	8.3	126	14.7	280	11.0
115	10.7	133	9.7	281	10.3
119	10.7	135	9.7	282	11.7
120	15.7	137	12.0	289	6.0
124	11.3	145	8.0	296	10.7
125	11.7	146	7.3	297	10.7
126	11.0	147	11.3	300	14.0
129	14.7	148	10.0	303	12.0
130	14.7	153	18.0	305	14.0
132	13.0	154	6.3	308	14.0
133	10.3	162	10.3	311	9.7
134	10.0	164	12.3	312	11.0
B 1.		168	12.7	314	14.7
18	9.0	170	15.7	317	9.7
25	7.3	173	11.0	321	12.0
26	12.0	174	15.7	335	9.0
31	12.0	175	8.3	337	11.3
34	8.3	177	10.0	338	10.0
37	9.7	B 2.		339	12.0
38	13.3	183	13.3	344	11.3
41	11.0	188	8.0	347	11.0
46	8.0	192	9.0	348	11.0
49	10.7	195	8.0	349	12.7
50	11.0	196	9.0	350	8.0
58	14.0	197	8.3	351	10.3
66	9.3	199	12.3	352	14.0
68	12.0	203	10.3	360	11.0
69	6.3	204	13.0	361	13.7
71	15.3	206	16.7	362	9.0
75	8.3	207	14.7	364	15.3
79	11.0	208	13.3	365	8.0
81	17.0	210	11.7	366	7.0
82	13.3	211	11.7	C 1.	
83	12.3	212	10.3	1	6.7
84	14.7	213	13.0	2	10.0
85	12.0	214	13.3	5	10.0

Experiment Station, Peradeniya

Block VII. (Hilltop—contd.)

<i>Tree.</i>	<i>Mean No. of l. v. rows.</i>	<i>Tree.</i>	<i>Mean No. of l. v. rows.</i>	<i>Tree.</i>	<i>Mean No. of l. v. rows.</i>
8	10.0	175	8.3		C 5.
11	9.3	176	12.7	334	8.3
13	12.3	178	15.0	342	11.7
14	6.7	181	14.3	344	12.7
18	14.7	184	11.0	346	11.3
22	14.0	189	14.0	347	9.7
23	17.7	193	9.7	349	9.7
27	6.0	196	9.0	350	12.7
29	9.0	197	14.3	351	11.7
32	13.7	201	8.0	355	12.7
33	10.0	202	13.0	356	7.0
35	10.0	205	10.0	357	13.3
36	7.7	206	10.0	359	12.3
41	9.0	208	11.3	361	8.7
45	6.3	212	11.3	362	10.0
48	10.0	214	12.7	363	8.0
49	8.3	219	12.3	367	13.0
50	12.7	221	8.7	370	13.7
53	13.7	224	13.3	371	11.7
65	11.3	228	8.7	372	15.3
69	15.0	230	15.3	373	7.7
73	14.7	232	8.0	374	11.0
78	14.3	233	8.3	376	8.3
80	14.7	234	11.0	377	8.0
83	12.3	239	9.0	378	16.7
84	10.3	247	10.7	382	11.0
85	11.3			384	7.0
		C 4.		387	13.0
		252	9.3	395	10.0
	C 2.	255	15.7	398	14.0
99	7.7	259	9.0	399	10.7
102	11.3	261	9.0	401	9.3
104	10.7	262	14.3	402	8.3
112	14.3	263	8.7	406	10.7
113	14.3	264	10.0	408	10.3
114	12.3	265	10.3	409	9.0
116	11.0	270	10.0	410	10.0
120	7.7	275	8.7	411	5.0
123	9.0	277	13.7	418	4.3
125	14.0	290	10.3	424	10.3
129	6.7	295	13.0	425	11.7
133	12.7	302	12.3	426	20.0
140	8.0	306	6.7	428	15.0
141	14.3	309	12.0	430	8.3
144	15.0	310	13.0	432	6.7
146	14.7	311	11.0	433	10.7
147	15.3	315	11.7	434	15.3
148	15.7	316	11.0	435	8.3
153	12.3	318	12.3	437	5.7
155	10.7	320	9.0	438	12.3
163	12.7	321	12.7		
		322	10.0		
	C 3.	326	10.7		C 6.
165	6.7	328	9.3	441	11.7
167	12.0	331	12.0	442	7.7
172	9.0			448	9.0

Experiment Station, Peradeniya

Block VII. (Hilltop—contd.)

<i>Tree.</i>	<i>Mean No. of l. v. rows.</i>	<i>Tree.</i>	<i>Mean No. of l. v. rows.</i>	<i>Tree.</i>	<i>Mean No. of l. v. rows.</i>
449	7.0	474	11.0	502	8.0
452	15.3	480	11.3	503	7.0
457	13.0	481	13.0	510	11.3
461	10.0	482	11.0	511	13.0
462	14.3	484	9.3	512	10.0
465	16.3	486	8.7	514	10.0
466	24.3	487	13.0	519	8.0
469	12.0	488	11.0	521	10.0
		493	8.0	523	10.0
	C 6.	495	10.0	524	12.3
		496	14.7	527	11.0
		497	10.3	532	9.3
470	6.3	498	10.0	535	14.7
471	9.3	500	11.7	536	7.0
473	9.3	501	10.0	538	7.0

Block VIII. (Hillside)

I.					
4	6.3	68	15.3	150	16.0
6	8.7	72	9.7	152	9.0
7	8.0	73	9.3	155	9.7
8	11.7	74	12.0	158	9.3
9	7.7	78	12.3	159	15.0
11	8.7	81	14.7	161	11.3
12	10.3	88	7.3	165	16.3
13	11.3	89	6.3	170	10.0
17	19.0	91	20.7	173	16.3
18	8.3	92	12.0	175	12.3
33	9.0	94	15.7	181	12.7
35	10.3	96	7.7	185	14.7
36	10.7	101	19.0	194	7.3
38	10.3	102	8.7	198	12.0
39	9.0	103	7.7	199	9.0
40	13.3	106	7.7	202	13.3
43	9.3	107	13.7	205	9.0
45	11.7	109	12.3	208	7.7
46	9.7	110	9.3	209	13.3
47	9.7	111	11.7	211	13.7
48	15.3	113	13.3	113	16.7
49	16.0	115	13.0	215	10.7
50	9.0	116	9.7	220	16.3
52	10.7	120	11.0	222	11.7
53	10.0	123	8.3	224	11.7
54	11.3	125	15.7	227	10.0
55	13.7	128	11.0	228	13.0
56	10.0	129	8.0	229	12.3
57	7.3			230	11.3
58	9.0	II.		231	12.3
59	7.3	139	10.7	232	10.3
61	8.0	140	10.3		
62	8.0	143	11.7	III.	
64	8.3	146	11.0	236	24.3
66	10.7	147	10.3	239	11.0
		149	8.7	240	11.0

Experiment Station, Peradeniya

Block VIII. (Hillside—contd.)

<i>Tree.</i>	<i>Mean No. of l. v. rows.</i>	<i>Tree.</i>	<i>Mean No. of l. v. rows.</i>	<i>Tree.</i>	<i>Mean No. of l. v. rows.</i>
245	17.0	405	15.3	528	8.0
247	11.3	412	12.3	530	17.3
250	13.0	415	13.0	535	15.0
251	11.0	417	13.0		
252	12.3	418	17.3		VI.
261	11.0	419	11.3		
266	9.7	421	15.7	538	8.0
267	10.7	425	12.0	539	11.0
271	7.3			540	14.0
272	14.0			542	13.0
278	9.0	V.		548	10.0
280	14.3	428	13.0	549	18.3
282	11.3	429	11.3	550	13.0
283	10.7	430	10.7	554	14.7
285	8.0	431	14.7	555	14.3
290	9.0	436	12.7	560	13.3
293	14.3	437	8.0	564	6.0
295	10.7	438	15.3	565	11.0
299	13.0	439	15.3	566	10.0
300	8.7	445	14.7	572	11.3
305	18.0	446	9.7	576	15.7
307	15.3	447	7.7	580	9.0
313	10.7	448	8.7	585	14.3
315	10.3	450	11.3	594	15.3
316	11.0	453	17.3	595	11.3
317	12.3	455	11.3	597	11.7
318	8.3	457	16.7	599	7.0
324	13.7	458	11.0	600	9.7
325	17.3	459	14.7	601	13.7
330	15.0	460	15.7	607	9.0
332	20.0	464	14.7	609	10.0
		465	11.7	612	9.0
IV.		466	10.7	613	12.3
		471	10.0	614	14.3
		472	14.7	617	13.0
334	10.0	476	13.3	619	13.3
341	14.0	477	14.7	620	13.0
342	15.7	481	11.0	622	12.7
345	12.3	484	13.7	627	9.3
347	15.3	487	7.7	628	11.0
349	11.0	488	11.7	634	18.3
354	8.7	489	9.7	636	11.0
355	5.0	490	14.7	637	9.3
359	9.3	492	14.3		
361	11.3	493	15.0		
364	11.3	497	11.3		
366	12.0	498	13.0		
370	9.3	499	16.7		
375	12.3	500	12.0		
380	18.3	501	10.7		
385	16.3	507	11.0		
388	13.0	510	11.7		
399	12.3	513	13.0		
400	15.3	520	13.7		
404	14.0	521	19.3		

Experiment Station, Peradeniya

Bandaratenne Rubber

<i>Tree.</i>	<i>Mean No. of l. v. rows.</i>	<i>Tree.</i>	<i>Mean No. of l. v. rows.</i>	<i>Tree.</i>	<i>Mean No. of l. v. rows.</i>
1	10.7	57	10.3	113	8.7
2	8.0	58	14.7	114	8.3
3	9.3	59	7.7	115	15.3
4	8.7	60	6.7	116	9.3
5	13.3	61	9.0	117	9.0
6	9.0	62	9.7	118	14.0
7	7.7	63	6.7	119	15.7
8	13.7	64	12.0	120	10.7
9	9.7	65	9.3	121	13.0
10	8.3	66	13.7	122	17.7
11	9.0	67	6.3	123	11.3
12	11.7	68		124	13.0
13	9.0	69	10.3	125	11.7
14	10.3	70		126	7.7
15	11.3	71	9.7	127	12.7
16	6.7	72	13.3	128	11.7
17	7.7	73	12.7	129	7.7
18	8.7	74	13.7	130	7.3
19	5.0	75	13.7	131	10.7
20	6.0	76	8.3	132	9.7
21	8.0	77	9.0	133	9.3
22	11.0	78	8.0	134	9.3
23	7.0	79	9.7	135	7.3
24	9.7	80	6.3	136	8.0
25	7.7	81	9.0	137	9.3
26	9.0	82	9.3	138	6.7
27	11.7	83		139	12.3
28	12.0	84	12.0	140	6.0
29	11.3	85	11.7	141	9.0
30	7.7	86	11.0	142	7.3
31	9.3	87	8.0	143	9.3
32	8.7	88	12.7	144	10.0
33	7.0	89	10.0	145	11.0
34	10.7	90	11.0	146	13.3
35	13.3	91	9.3	147	16.0
36	11.3	92	12.7	148	12.3
37	7.0	93	9.0	149	9.7
38	11.7	94	12.3	150	5.0
39	11.0	95	4.3	151	11.3
40	8.0	96	12.7	152	6.0
41	7.0	97	8.3	153	7.3
42	6.0	98	9.0	154	6.3
43	8.0	99	14.3	155	8.3
44	10.3	100	10.7	156	10.0
45	12.3	101	14.7	157	8.3
46	7.3	102	7.0	158	11.3
47	11.3	103	5.0	159	8.0
48	10.7	104	14.0	160	9.3
49	9.3	105		161	9.0
50	11.3	106	9.0	162	9.0
51	6.3	107	9.7	163	11.7
52	7.7	108	8.7	164	12.7
53	8.3	109	8.7	165	14.7
54	10.3	110	11.3	166	11.3
55	10.7	111	10.3	167	6.7
56	9.7	112	7.0	168	6.0

Experiment Station, Peradeniya

Bandaratenne Rubber.—(contd.)

<i>Tree.</i>	<i>Mean No. of l. v. rows.</i>	<i>Tree.</i>	<i>Mean No. of l. v. rows.</i>	<i>Tree.</i>	<i>Mean No. of l. v. rows.</i>
169	11.7	226	8.0	283	3.0
170	15.0	227	8.3	284	8.0
171	6.7	228	7.3	285	10.3
172	7.0	229	9.3	286	9.0
173	9.3	230	6.3	287	8.3
174	10.3	231	6.0	288	13.0
175	10.7	232	13.0	289	14.7
176	9.3	233	7.7	290	3.0
177	7.3	234	11.0	291	8.7
178	12.0	235	10.0	292	10.3
179	9.7	236	10.7	293	4.3
180	5.7	237	11.0	294	7.3
181	8.0	238	13.3	295	5.7
182	10.7	239	12.0	296	8.0
183	10.3	240	8.7	297	7.3
184	8.0	241	14.0	298	10.7
185	10.0	242	13.7	299	6.7
186	5.7	243	8.0	300	9.3
187	5.0	244	6.0	301	9.3
188	8.3	245	9.3	302	8.7
189	9.0	246	10.0	303	10.3
190	9.0	247	10.3	304	5.3
191	7.7	248	6.7	305	5.0
192		249	10.7	306	5.0
193	8.0	250	5.0	307	8.0
194	12.0	251	7.0	308	6.7
195	11.7	252	7.7	309	7.7
196	8.0	253	6.3	310	9.7
197	5.0	254	5.7	311	8.0
198	10.3	255	7.7	312	8.0
199	7.3	256	10.3	313	8.7
200	14.0	257	16.7	314	8.3
201	8.0	258	11.0	315	5.7
202	9.3	259	11.0	316	7.0
203	10.0	260	8.7	317	3.3
204	7.3	261	11.3	318	7.7
205	7.3	262	10.7	319	
206	14.3	263	6.0	320	9.7
207	10.0	264	7.0	321	5.0
208	15.0	265	6.3	322	11.7
209	9.3	266	6.0	323	
210	12.3	267	5.7	324	5.3
211	7.7	268	12.7	325	11.7
212	8.7	269	9.0	326	10.3
213	7.3	270	12.3	327	6.3
214	7.3	271	10.3	328	5.3
215	6.7	272	5.7	329	7.7
216	10.0	273	5.0	330	8.0
217	8.7	274	10.3	331	4.7
218	14.3	275	11.3	332	9.7
219	11.0	276	8.3	333	7.3
220	11.7	277	9.0	334	
221	4.3	278	14.7	335	5.7
222	7.7	279	9.7	336	7.7
223	8.0	280	5.3	337	5.7
224	6.0	281	6.3		
225	7.3	282	6.7		

Heneratgoda Gardens

Plot I.

<i>Tree.</i>	<i>Mean No. of l. v. rows.</i>	<i>Tree.</i>	<i>Mean No. of l. v. rows.</i>	<i>Tree.</i>	<i>Mean No. of l. v. rows.</i>
1	26.3	15	16.7	27	13.0
2	54.7	16	25.0	28	23.0
3	29.3	17	24.3	29	10.3
6	29.3	18	32.0	30	18.0
7	31.3	19	23.3	31	26.0
8	32.0	20	21.0	32	17.7
9	21.0	21	16.3	33	17.7
10	23.0	22	24.3	34	15.0
11	27.3	23	21.0	35	12.3
12	20.3	24	23.7	36	27.0
13	15.0	25	12.3	37	26.0
14	19.7	26	19.7	38	20.7

Plot II

84	22.0	130	12.7	172	18.0
85	25.7	131	25.7	173	15.0
86	39.7	133	18.0	174	20.0
87	20.7	134	13.0	175	14.0
88	36.0	135	14.7	176	18.0
89	21.7	136	17.0	177	23.0
90	14.7	137	17.7	178	19.7
91	20.7	138	16.0	179	11.0
92	24.3	139	15.0	181	17.0
93	18.3	140	25.3	182	17.3
94	21.3	141	15.7	185	15.0
95	17.0	142	10.0	190	20.0
96	13.7	143	10.0	198	25.0
98	22.0	144	17.0	199	16.7
99	14.7	145	10.7	200	19.3
100	22.7	146	17.3	201	11.0
101	18.3	147	13.0	203	42.0
102	16.3	148	9.7	204	11.0
103	21.0	149	13.7	211	15.7
104	16.7	150	13.0	212	11.0
105	14.7	152	17.7	213	16.0
108	13.0	153	17.0	217	13.0
109	24.0	154	15.3	218	15.0
110	23.7	155	12.7	219	8.0
111	34.7	156	21.0	221	30.0
114	19.3	157	16.7	223	14.7
115	23.0	159	20.0	224	16.7
116	13.7	160	7.0	228	14.0
117	17.3	161	18.0	229	11.7
118	10.0	162	14.0	230	18.0
119	15.0	163	10.3	231	9.3
121	18.0	164	19.3	232	24.7
122	15.7	165	7.7	233	8.0
123	20.3	166	12.3	234	19.3
124	28.3	167	14.0	235	17.0
125	11.7	168	15.3	236	13.0
126	14.0	169	14.3	237	16.0
127	17.7	170	14.0	238	17.0
128	18.0	171	13.7	239	12.7

Heneratgoda Gardens

Plot II. —(contd.)

<i>Tree.</i>	<i>Mean No. of l. v. rows.</i>	<i>Tree.</i>	<i>Mean No. of l. v. rows.</i>	<i>Tree.</i>	<i>Mean No. of l. v. rows.</i>
240	23.0	255	6.3	276	10.0
241	8.7	256	9.0	277	16.0
242	11.3	257	13.0	278	11.3
243	13.3	258	8.3	279	16.3
244	12.3	259	14.7	280	18.3
245	23.0	260	13.0	281	10.3
246	20.3	261	12.3	282	10.0
247	21.0	262	15.3	286	13.0
248	15.3	263	15.3	287	19.3
249	22.7	267	13.0	288	16.3
250	24.3	268	15.0	289	16.0
251	19.0	269	17.0	290	14.7
252	20.0	270	13.3	291	23.0
253	11.0	271	22.3	292	16.7
254	18.3	273	9.0	293	12.3

Plot III

299	12.3	324	14.0	350	22.7
300	20.0	325	16.0	351	14.0
301	16.0	327	24.3	352	15.3
302	18.7	328	20.0	353	8.0
303	17.0	329	14.0	354	19.0
305	22.0	330	10.0	355	31.0
306	17.7	333	16.0	356	23.0
307	22.0	334	24.3	357	20.0
308	20.3	335	27.7	358	16.3
309	19.0	336	13.0	359	16.0
310	20.7	338	10.7	360	6.3
311	15.0	339	14.3	361	7.7
312	27.7	340	21.0	362	22.7
313	15.0	341	16.3	363	26.7
315	20.0	342	15.3	364	16.0
316	25.3	344	22.0	365	13.0
317	11.0	345	17.0	366	23.0
318	27.7	346	15.0	367	23.7
321	15.7	347	11.3	368	20.0
322	13.7	348	23.0		
323	18.0	349	31.7		

Riverside

369	18.0	381	20.0	398	17.7
370	22.0	382	19.7	399	11.3
371	31.7	383	37.3	400	41.0
372	15.3	384	23.0	401	32.3
373	26.7	385	29.0	402	17.7
374	24.0	386	20.0	403	16.7
375	12.7	390	24.3	404	20.3
376	20.0	391	22.7	405	15.0
377	23.0	395	26.3	406	19.7
378	23.3	396	23.0	407	33.0
379	15.0	397	30.3	411	32.0

Heneratgoda Gardens

Riverside—(contd.)

<i>Tree.</i>	<i>Mean No. of l. v. rows.</i>	<i>Tree.</i>	<i>Mean No. of l. v. rows.</i>	<i>Tree.</i>	<i>Mean No. of l. v. rows.</i>
413	15.7	435	22.3	459	15.0
414	14.7	436	19.0	460	19.7
415	12.7	437	29.7	461	15.0
416	18.7	438	21.3	462	16.7
418	24.3	439	39.0	463	29.7
420	24.7	440	32.7	464	31.3
421	18.0	441	29.7	465	17.3
423	23.0	442	25.3	466	19.7
424	24.0	443	16.0	467	22.7
425	15.0	444	30.3	468	16.0
426	26.0	445	28.7	469	20.0
427	17.7	451	19.3	470	15.0
428	29.7	452	15.0	471	19.0
429	12.7	453	20.0	472	12.0
430	17.0	454	19.0	473	19.7
431	17.0	455	26.3	474	21.0
432	16.0	456	12.0	475	15.0
433	16.7	457	26.7	476	19.0
434	26.7	458	14.3		

Plot IV

48	26.0	62	23.3	74	24.7
51	18.3	63	18.0	75	25.0
52	13.0	64	18.3	76	18.0
53	25.3	65	12.0	77	18.3
54	18.7	66	18.7	78	14.7
55	24.7	67	15.7	79	21.0
56	21.0	68	23.3	80	20.0
57	15.3	69	10.0	81	14.3
58	21.3	70	24.3	82	22.3
59	18.0	71	37.0	83	13.7
60	26.3	72	28.0		
61	13.0	73	20.7		

Progeny No. 2

1	17.7	17	13.7	33	13.3
2	24.7	18	15.7	34	16.0
3	19.3	19	16.0	35	26.7
4	13.0	20	15.0	36	17.7
5	15.7	21	16.7	37	17.7
6	25.0	22	16.3	38	15.7
7	13.3	23	15.7	39	11.0
8	14.7	24	23.7	40	11.7
9	25.7	25	17.0	41	9.3
10	16.3	26	16.7	42	17.7
11	29.0	27	14.7	43	25.0
12	14.7	28	13.0	44	18.3
13	12.0	29	15.3	45	25.0
14	12.3	30	16.7	46	16.0
15	11.0	31	20.7	47	9.0
16	8.3	32	14.0	48	25.0

Heneratgoda Gardens

Progeny No. 2—(contd.)

<i>Tree.</i>	<i>Mean No. of l. v. rows.</i>	<i>Tree.</i>	<i>Mean No. of l. v. rows.</i>	<i>Tree.</i>	<i>Mean No. of l. v. rows.</i>
49	19.3	68	19.0	83	16.3
50	13.7	69	14.7	84	21.7
51	16.0	70	12.7	90	11.3
52	19.7	71	14.7	91	15.7
53	25.3	72	20.7	92	19.0
54	18.3	73	15.0	93	16.7
55	17.0	74	13.7	94	10.7
59	18.7	75	17.3	95	14.3
60	10.0	76	10.0	96	18.0
62	23.7	77	13.3	97	15.7
63	11.7	78	12.0	98	13.0
64	11.7	79	17.0	99	21.0
65	20.3	80	17.3	100	18.0
66	11.0	81	20.0	106	20.0
67	17.3	82	24.0		

Plot V

1	10.0	18	16.7	35	10.7
2	18.3	19	10.3	36	14.7
3	11.3	20	14.3	37	11.3
4	18.0	21	16.7	38	12.3
5	14.3	22	11.7	39	14.3
6	10.0	23	13.7	40	15.0
7	13.0	24	14.0	41	16.0
8	11.3	25	15.0	42	16.3
9	14.0	26	12.0	43	9.7
10	14.7	27	17.3	44	15.3
11	15.3	28	12.3	45	8.7
12	10.0	29	10.7	46	10.7
13	11.0	30	12.0	47	16.0
14	15.0	31	16.0	48	18.7
15	14.7	32	12.0	49	14.7
16	15.3	33	15.0		
17	16.0	34	17.7		

Blackseeded

1	15.7	11	9.3	21	21.7
2	14.7	12	8.0	22	11.0
3	16.3	13	8.7	23	9.3
4	11.4	14	9.3	24	21.0
5	16.3	15	24.0	25	13.3
6	19.7	16	21.0	26	22.3
7	14.3	17	17.7	27	15.0
8	16.3	18	10.0	28	12.3
9	14.0	19	14.7	29	15.7
10	21.7	20	11.3		

Royal Botanic Gardens, Peradeniya

<i>Tree.</i>	<i>Mean No. of l. v. rows.</i>	<i>Tree.</i>	<i>Mean No. of l. v. rows.</i>	<i>Tree.</i>	<i>Mean No. of l. v. rows.</i>
1	29.0	11	27.0	21	27.0
2	19.7	12	24.3	22	20.0
3	22.3	13	24.0	23	19.7
4	29.7	14	32.7	24	30.0
5	26.3	15	23.0	25	23.3
6	27.7	16	26.7	26	31.3
7	26.7	17	22.7	27	26.0
8	27.0	18	28.3	28	24.0
9	24.7	19	23.3		
10	23.0	20	19.0		

(Received for publication July 9th, 1927).

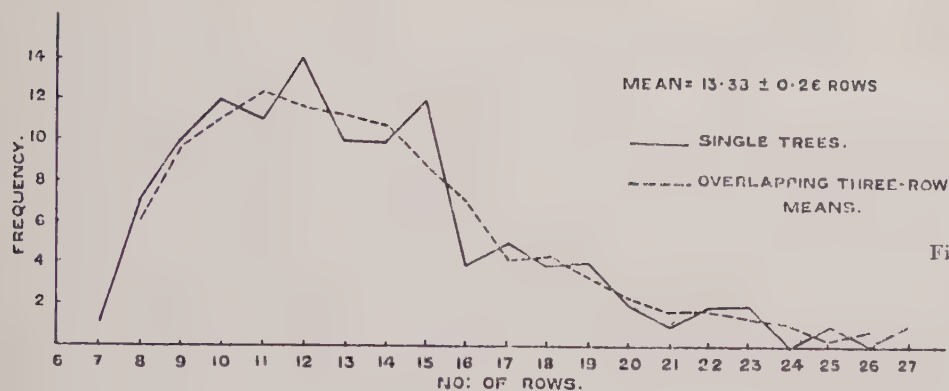


Fig. 1

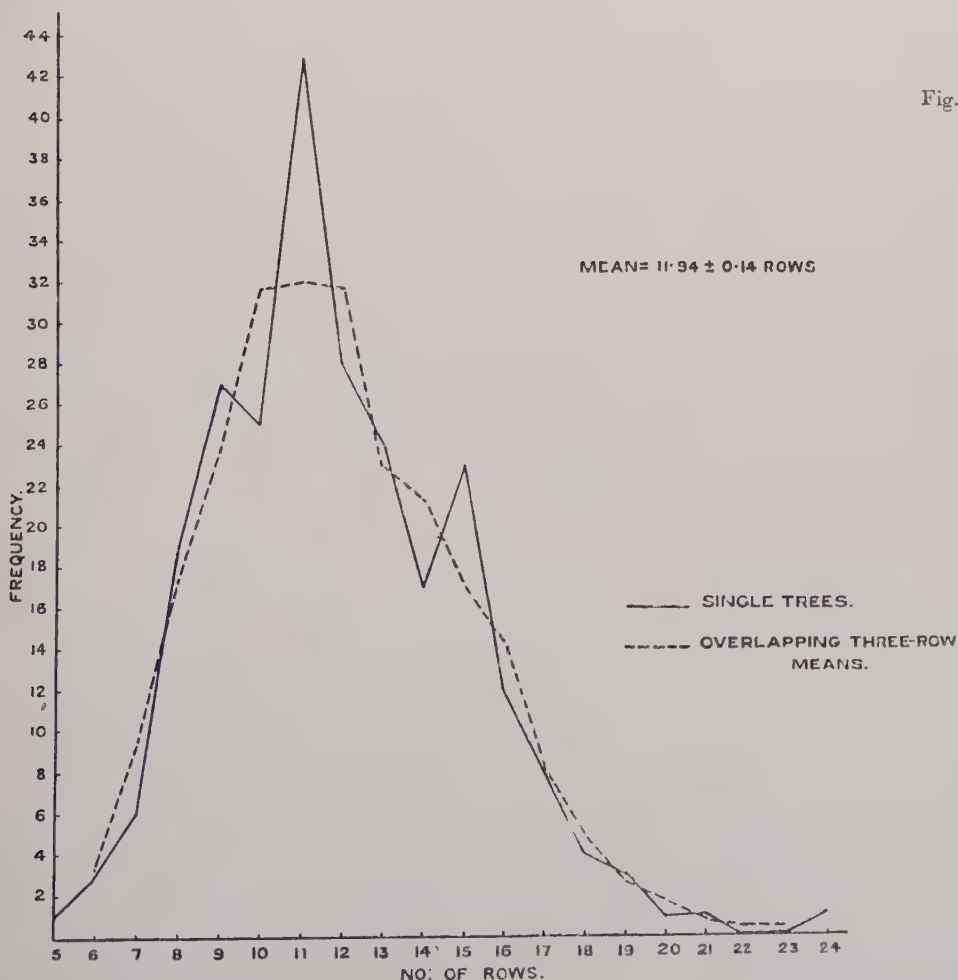


Fig. 2

Fig. 1.—Frequency Polygon of latex-vessel rows of Avenue Rubber (Plots 68-76) Experiment Station, Peradeniya.

Fig. 2.—Frequency Polygon of latex-vessel rows of Hillside Rubber, Experiment Station, Peradeniya.

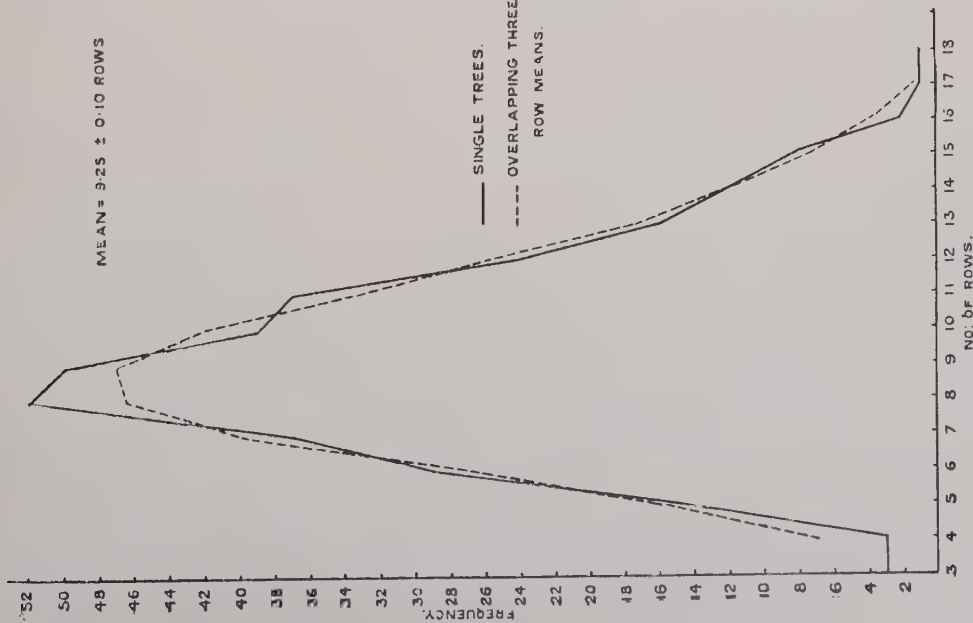
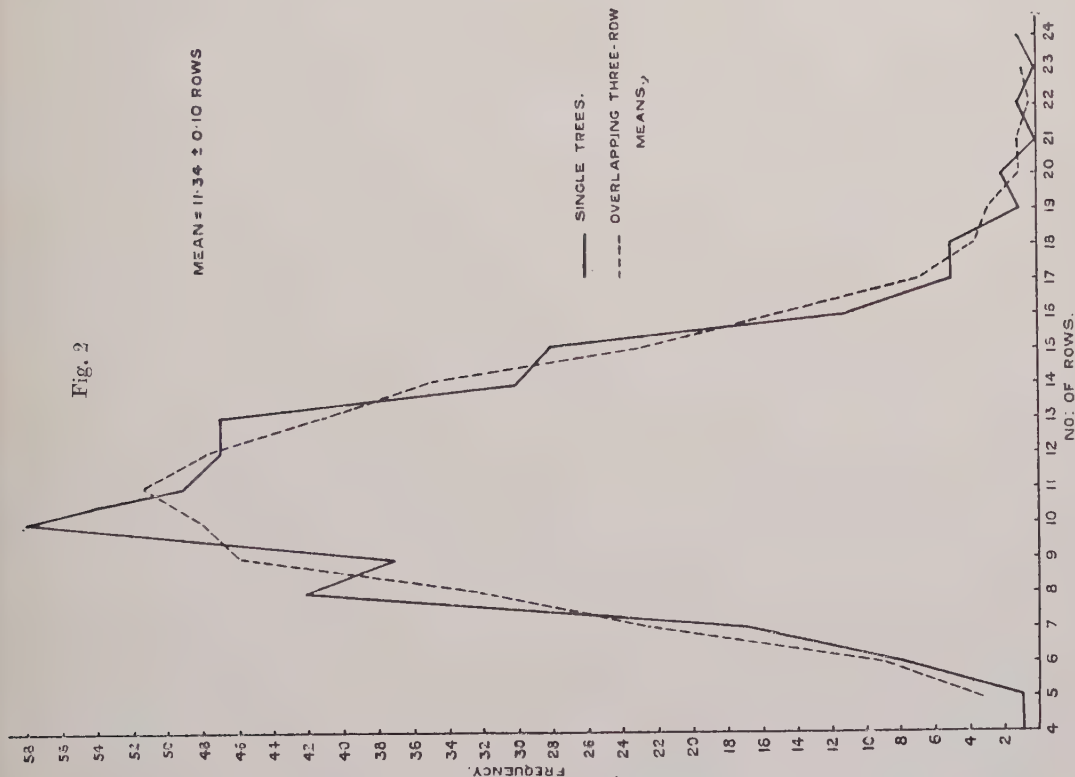


Fig. 1.—Frequency Polygon of latex-vessel rows of Bandaratenne Rubber, Experiment Station, Peradeniya.
Fig. 2.—Frequency Polygon of latex-vessel rows of Hill-top Rubber, Experiment Station, Peradeniya.



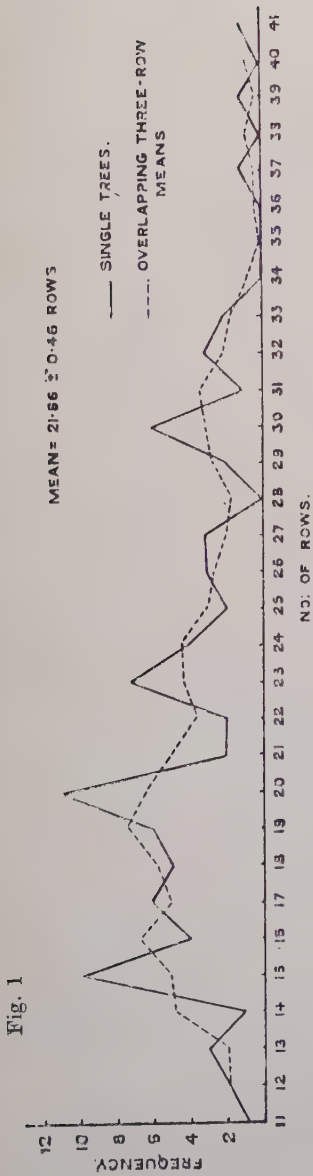


Fig. 2

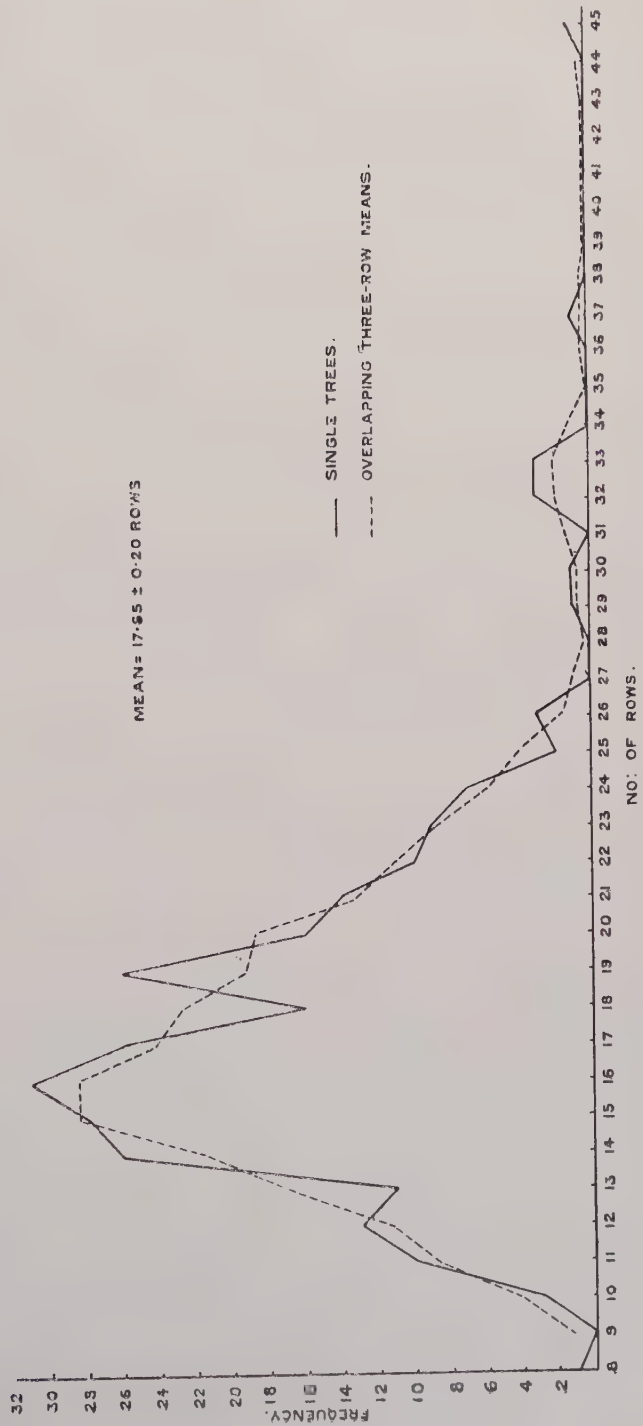


Fig. 1.—Frequency Polygon of latex-vessel rows of Riverside Rubber, Henaratgoda.
 Fig. 2.—Frequency Polygon of latex-vessel rows of Plots 78-86, Experiment Station, Peradeniya.

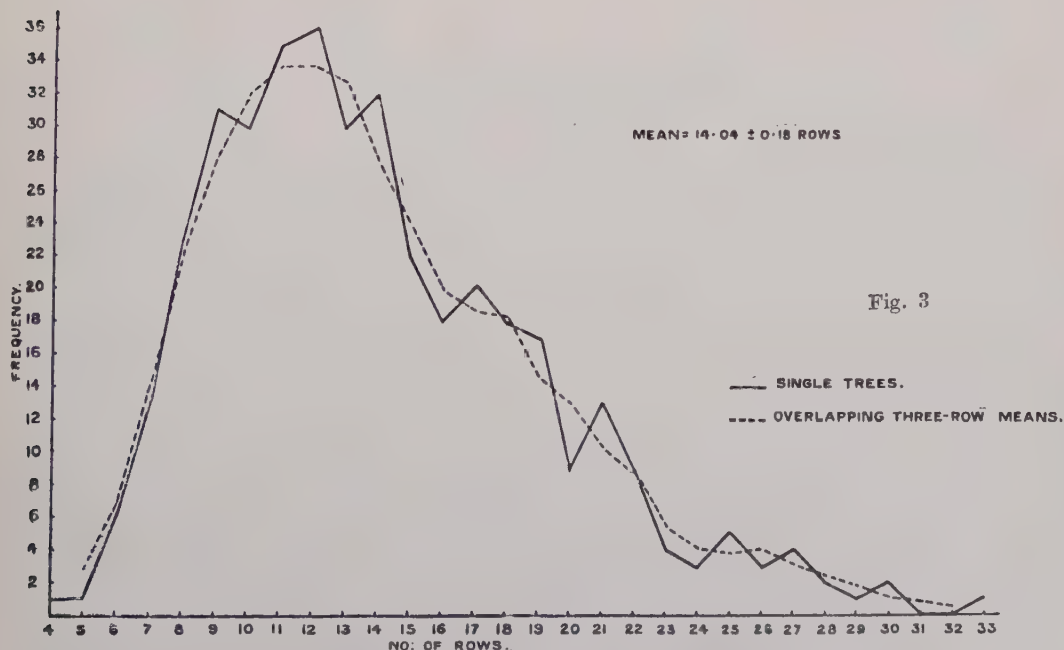
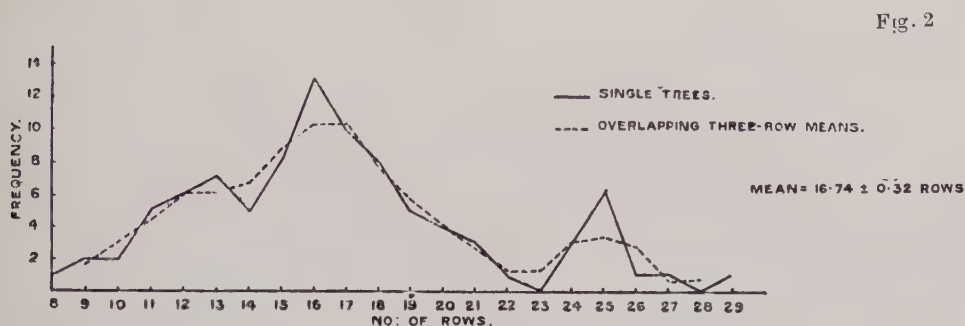
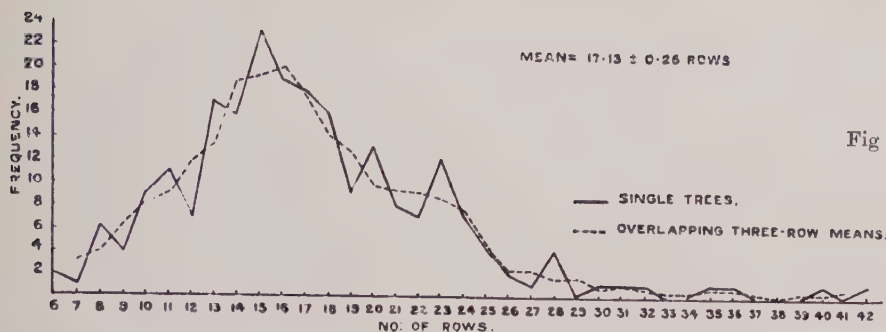


Fig. 1.—Frequency Polygon of latex-vessel rows of Plots II and III, Heneratgoda.

Fig. 2.—Frequency Polygon of latex-vessel rows of Progeny No. 2, Heneratgoda.

Fig. 3.—Frequency Polygon of latex-vessel rows of Plots 151-154, Experiment Station, Peradeniya.

Notes on Some Ceylon Plants

BY

E. J. Livera, B. Sc. (Lond.)

Assistant in Systematic Botany, Department of Agriculture, Ceylon

These notes are intended to serve as corrections and additions to Trimen's Flora of Ceylon. They include descriptions of two new species, a new variety, two known species recently found in Ceylon, and an amended description of *Cirrhopetalum Trimeni* Hk. f.

Polycarpaea spicata Wight and Arn. in Ann. Mag. Nat. Hist., III, p. 91 (1839).

A small, glabrous herb, 2-3 in. high; branches terete, slender, ascending and spreading, bearing whorls of leaves and terminating in cymes. Leaves petioled, 0.25-0.5 in. long, obovate-spathulate, rather fleshy, nerveless; radical leaves rosulate; stipules scarious, lacerate. Cymes short and fascicled or long and sub-umbellate, long-peduncled. Flowers subspicate, crowded, about 0.15 in. long. Bracts about 0.075 in. long, ovate, acute, scarious. Sepals 0.15 in. long, ovate-lanceolate, acute, scarious, white with a highly coloured, broad, herbaceous midrib, and much exceeding the petals. Petals 5, very small, oblong, obtuse. Stamens 5. Ovary 1-celled; style minute, 3-fid; ovules numerous. Capsule 3-valved, more than half the length of the sepals within which it is enclosed. Seeds obovoid, shining.

Specimens sent in by the Hon. Mr. J. P. Lewis, 8th December, 1903, from the Islands off the Jaffna Peninsula.

Heliotropium curassavicum Linn. Sp. Pl. ed. 1, p. 130. (1753).

Stems glabrous and prostrate, terete, very woody and much branched at the base. Leaves rather fleshy, linear-lanceolate, glabrous, obtuse, narrowed to a short petiole; the lower leaves 1-1.25 in. long, the upper smaller. Spikes solitary or in pairs, 1-3 in. long, ebracteate, fairly dense. Calyx 0.1 in. long, glabrous; tube none; segments ovate. Corolla tube as long as the calyx; lobes oblong. Style very short; stigma large, umbrella-shaped, blunt. Fruit globose, as long as the calyx; nuts 4, glabrous.

This species is not found in India. Specimens were first collected in Jaffna in March, 1912; and subsequently in January, 1914, by Herr Rehnelt.

Plectranthus Gardneri Thw. var. Jowittii Willis in Ann. Perad. V, p. 220 (1911), "No. 67, a well-marked form to be described later."

There are three sheets of *Plectranthus* in the Peradeniya herbarium, collected from Naminukula on the 29th April, 1907. Two of these, (one of which has "pink-flowered" written on it), have been labelled "*Plectranthus Gardneri* Thw." by Willis, and the third "*Plectranthus* fls. white, near *Gardneri*," only the last two words being in Willis' hand-writing. The specimens on this sheet do not differ in any respects either from the other specimens collected at the same time from the same locality, or from the other specimens of *P. Gardneri* Thw. in the herbarium. It is very probable that the sheet labelled "Near *Gardneri*" is the one Willis intended to name *P. Gardneri* var. *Jowittii*. This specimen differs from the type only in having white instead of pink flowers.

Cirrhopetalum Trimeni Hk. f. in Trimen's Flora of Ceylon, IV (1898), p. 158.

"Rhizome with short internodes, much branched, pseudo-bulbs globose-ovoid with one leaf. Leaf 0.75-1 in., oblong or oval-oblong, obtuse, emarginate, very thick and stiff. Scape from the base of the pseudo-bulb, very slender 1.5 in., glabrous, spotted with red," enclosed within two or three ochreate leaves. "Flower 6 to an umbel; bracts short, acute," triangular; pedicel 0.25-0.35 in. long; dorsal sepal 0.2 in. long, "oblong-oval, shortly acuminate, acute," 3-veined; lateral sepals 0.3-0.35 in., "not spreading," falcate, acute, 3-veined; lateral petals 0.1 in. long, 1-veined, "oval-oblong, obtuse, apiculate, slightly erose at the margin"; column winged, prolonged to a long upcurved foot; "lip tongue-shaped, thick, channelled above, blunt, strongly upturned," 0.1 in. long, articulate about the foot of the column; anthers operculate, terminal, 2-celled; pollinia 4, waxy, collateral, cohering in pairs by a viscus, ovoid.

Pale straw-colour, lip darker. Very small flowered, creeping on tree trunks, Hakgala, 18th September, 1894," 4th March, 1906, 5th October, 1906, *A. M. Smith*! 12th February, 1924, *Livera*!, Maskeliya 31.8.22, *S. B. Stedman*!, Kandapola 27th January, 1923, *A. N. Paine*!

Hooker f., (l.c.) made his description of this species from Trimen's manuscript notes, which are preserved in the herbarium, and he had no specimens at the time. Specimens, collected at different times from three different localities, agree with one another, but differ from Hooker's description in a few details. Passages in parenthesis, in the description given above, are from Trimen's manuscript notes.

The sixth line of the key to the Ceylon Cirrhopetalums in Trimen's Flora of Ceylon IV (1898) p. 157, should read

lateral sepal 3-nerved 3 C. TRIMENI

Smilax Rettiana Willis in Annals, R. B. C., Peradeniya, V (1911), p. 221, No. 94.

A scandent, glabrous, much branched, unarmed shrub; branches slender, flexuous, angular. Leaves 1·2–2·2 in. long, 0·5–1·2 in. broad, lanceolate, oval, or cordate, acute or acuminate, narrowed or cordate at the base, peltate, joined or not on the petiole, 3-veined, veins prominent on both surfaces, coriaceous, margins cartilaginous; petiole 0·1–0·15 in. long, base sheathing, 2-cirrhiferous; inflorescence umbellate; fl. not seen; fruit about 0·4 in. in diameter.

Naminakulikanda. Flowers September and March.

Endemic.

In his paper on "Naminakulikanda," Willis (l.c.) enumerated among other plants "*Smilax Rettiana* Willis. A new species, to be described in a later paper" and mentioned (op. cit. p. 222) this "one endemic species, *Smilax Rettiana*" as the only endemic species found there. The specimens, collected on the 25th October, 1910, are preserved in the Peradeniya Herbarium. Later specimens were collected in April, 1924.

Mariscus Thwaitesii Livera n. sp. Thwaites C.P. 4018. *Cyperus puncticulatus* Vahl var. *spic. brevior* Hooker Mss.

Radix fibrosa. Culmus solitarius, bipedalis vel longior, crassiusculus, sursum triquetrus. Folia plura, culmo longiora, basi breviter vaginata. Involucri bracteae 3–4, usque ad unipedales longae, divaricatae. Umbella 2–3 poll. diam., rigida, divaricata; radii 5, usque ad 4 poll. longi; ochreae 0·25–0·4 poll. longae, apice bidentatae. Umbellularum radioli 1–3, subcorymbosi, divaricati; bracteolae parvae, rarius 0·5 poll. longae. Spicae 1 poll. longae, 8–20 spiculosae; rachis glabra; spiculae undique pyramidalatim patentes, ovatae, subteretes, supra glumam secundam articulatum caducae, 8–14-florae, pallidae, subturgidae; rhachilla alternatim excavata; alae hyalinae, insolubiles. Glumae semper imbricatae, concavae, orbiculares, obtusae, margine membranaceae, brunneae. Stamina 3; antherae lineari-clongae, muticae. Stylus nuce longior; rami 3 longiusculi. Nux obovoidae, acute trigona, cum $\frac{3}{4}$ parte glumae aequilonga, nigra.

These specimens were labelled by Thwaites "*Cyperus* sp. C. P. 4018," and were not mentioned in his "Enumeratio Plantarum Zeylaniae" (1864) as they were probably collected after the publication of that work. Trimen annotated it "Conf *C. procerus*. *C. puncticulatus*, spikelets shorter." Hooker f., added "*puncticulatus* Vahl? var. *spic. brevior*"

and referred to it in Trimen's Flora of Ceylon V (1900) p. 21 : under *C. puncticulatus* Vahl.

As these specimens have persistent glumes, a trifid style, the spikelets deciduous above the two lowest empty glumes, and the rhachilla continuous at the base, they cannot belong to the genus *Cyperus*. They differ from *Mariscus albescens* Gaud, the nearest Ceylon species in having slender root-fibres, a less crowded umbel, flatter and shorter spikelets.

Root-fibres filiform. Stem slender, strong, solitary 2 ft. or more, erect, base terete, apex triquetrous, angles spiny, spines irregularly scattered. Leaves usually longer than the stem, (the outermost reaching only half the length of the stem), 0.12-0.5 in. broad, about 0.075 in. thick, 1-veined, pale beneath, margin smooth striate suberose linear, apex filiform, sheath short. Involucre bracts 3-4 foliaceous, only one reaching a foot in length and being longer than the umbel. Umbel simple or compound, about 5 rays, each about 0.6 in. broad, varying in length from 1-4 in., several of them branching into three. Bracteoles very short, rarely 0.5 in. long. Ochrea 2-toothed as apex. Spikes rather distant on a slender angular rachis of about an inch in length. Spikelets of 8-14 flowers on a slender, angular, undulate rhachilla with hyaline wings. Glumes 0.1 in. long, closely imbricate, thin, concave, orbicular, obtuse; margins broadly hyaline scarious, closely veined, mottled with brown, sides pale. Stamens 3, anthers $\frac{2}{3}$ length of the glume, as broad as the nut, 2-lobed, apex retuse. Nut minute, 3-sided concave, style persistent, about twice the length of the nut. Stigmas 3, capillary, very short.

Distribution unknown.

A note on Amu (*Paspalum scrobiculatum* L.)

BY

T. Petch, B.A., B. Sc.

In The Tropical Agriculturist for July, 1907, there appeared a Note on Amu Cultivation by Mr. T. B. Pohath-Kehelpañala, with criticisms by Mr. J. F. Jowitt, and further communications by the same authors, arising out of that note, were published in the same journal for September of that year.

Mr. Pohath-Kehelpañala claimed that there were two principal varieties and four minor varieties of Amu, viz. Karal Amu, Bada Amu, Pol or Polu Amu, Tawal Amu or Kaul, Gini Amu, and Wal Amu. As pointed out by Mr. Jowitt, these names do not all refer to varieties of *Paspalum scrobiculatum*. Tawal Amu is *Setaria glauca*, which is usually present to the extent of about fifty per cent. in samples of Amu. Fide Mr. Jowitt, Wal Amu is *Paspalum scrobiculatum* L.; Pol Amu is *P. scrobiculatum* var. alpha Kunth; and Karal Amu, Bada Amu, and Gini Amu come under vars. beta and gamma Kunth.

One of the chief points of interest arising out of these communications was the existence of a form known as Math Amu. Math means inebriating, and it is applied to an Amu which produces symptoms of intoxication or giddiness when eaten. It was, however, elicited by the discussion that there is no special variety Math Amu, but that any variety of Amu can become Math.

Mr. Pohath-Kehelpañala stated (p. 53) that Bada Amu was the variety which produced an inebriating effect on some constitutions and for that reason it was also called Math Amu. He repeated (p. 234) that it was generally the Bada Amu, not Karal Amu, which had that effect. He also stated (p. 53) that it was always advisable to eat Amu boiled as rice, rather than to use it in the raw state. The latter curious remark evidently refers to the two methods of preparing Amu for food, in one of which it is husked and then boiled, while in the other it is boiled, then husked, and again boiled.

Mr. Pohath-Kehelpañala mentioned that a reddish substance, which was known as Amu Kapuru (Amu Camphor), was sometimes found adhering to the grains of Bada Amu, and suggested that it was this substance which caused the Bada Amu to be Math.

From the correspondence, it appeared that Gini Amu could become Math, and that this effect was attributed to growth on unsuitable soil.

Further enquiries made at this time furnished the information that Karal Amu and Bada Amu were not considered poisonous by the villagers, but they boiled Math Amu in two lots of water, draining off and throwing away the first; this argues a recognition of Math Amu from the grain. Mr. Jowitt informed me that he had only once received a sample named Math Amu and that failed to germinate; he had heard of Amu Kapuru but had never seen it.

Amu Kapuru was said to occur on small patches in fields of Bada Amu. It was only discoverable at night, when it emitted sparks. When found it should be covered with a cloth and gathered next day. A field in which it occurred was always Math. Mr. Jowitt offered five rupees for specimens, but did not succeed in obtaining any.

From the facts that any variety of Amu can become Math, and that a substance was found adhering to the grains, there seemed a strong probability that the effect might be caused by a fungus. Attempts were made to investigate the matter, but it was not found possible to obtain either Math Amu or Amu Kapuru. Ten years later, the late Mr. van Buuren made further attempts to obtain material, but with no more success.

Paspalum scrobiculatum, in Ceylon, is frequently attacked by *Sorosporium Paspali* McAlp., but the spores of the latter do not form a red powder, and it is improbable that the smutted grain would be eaten, though the spores might adhere to the sound grain harvested at the same time. *Uredo Paspali-scrobiculati* Syd. is fairly common on the leaves, but has not been observed on the grain. There is, of course, the possibility that a mycelium of either of these fungi might be present in the fruits without producing spores.

It is of interest to note that the statement that Math Amu is luminous at night is paralleled by the tradition attached to the mandrake. The Anglo-Saxon version of the Herbarium Apuleii Platonici, states, *re Mandragora*, "When thou comest to it, then thou shalt recognise it by this, that it shineth at night altogether like a lamp" (J. F. Payne, English Medicine in the Anglo-Saxon times).

The Dictionary of the Economic Products of India records that two sorts of *Paspalum scrobiculatum* are well-known in the Bombay Presidency, one wholesome and the other unwholesome, but that all the varieties are, as a matter of fact, more or less poisonous, and unless special precautions are taken the grain is liable to act as a narcotic poison. It quotes the following, concerning the variety known in the Bombay Presidency as the black Kodra, from the Bombay Gazetteer, vol. XXV,

“The outer coat or husk has, according to Surgeon-Major Pyrie, a dark outline of a fungus-like character, and on the internal surface it appears to consist of minute roundish cells containing dark sporules. Several authorities have failed to recognise this fungus-like character, in which is supposed to reside the poisonous principle. The fact, however, that Kodra grain, freshly reaped, if left unstacked in the fields for some days when it was rainy and wet, had become possessed of decidedly more poisonous properties than grain from the same field harvested and stacked when the weather was dry, together with the generally acknowledged truth that a very poisonous seed has, under peculiarities of soil and cultivation, yielded a comparatively harmless grain, seems to bear out the fungus theory.” “Though every part of the grain is poisonous, the husk and testa are more so : hence the natives take good care to separate the light grain, by means of water in which it floats, from the heavy and less injurious one. Kodra grain is a common article of food with all the poor people in India. They prepare it by macerating it for three or four hours or more in a watery solution of cowdung, when the scum and hollow grain which rise to the surface are separated, and the good grain removed and spread out in the sun to dry. This process is repeated so long as any poison is suspected to remain in the grain. Boiling does not entirely destroy the poison, but if the grain is kept for a number of years, its poisonous properties are found to diminish. When required for use it is ground in earthen mills, which remove the pericarp : it is then pounded and winnowed and the grain is fit for use.”

The details of the foregoing quotation suggest that the poisonous effect is due to a fungus which attacks the grain during the harvesting rather than to a smut or rust fungus. The problem, however, does not appear to have received further investigation, and it is with the object of directing attention to it that this note has been compiled.

A similar case occurs in Ceylon with regard to Meneri, one form or variety of which is intoxicating, and hence is known as Kansa Meneri (Kansa=Ganga=*Cannabis sativa*). The name Meneri is applied to both *Panicum miliaceum* Linn. and *Panicum miliare* Lamk., and it has not been determined to which of these the variety Kansa Meneri belongs.

On Some Freshwater Algae from Ceylon,
collected by W. P. Lipsky in 1908

BY

B. W. Skvortzow

Manchuria Research Institute, Harbin, China

The following is a list of algae collected at Montlake near Colombo by the Russian botanist W. P. Lipsky in May, 1908. This collection was examined by me in the Petrograd Academy of Science in 1917. The sample contained a rich Zooplankton, among which were found the following algae:—

Phacotus lenticularis Stein.

Trachelomonas volvocina Ehrenb.

Microcystis flos aquae (Wittr.) Kirch.

Merismopedia tenuissima Lemm.

Lyngbya contorta Lemm. Very common.

Anabaena flos. aquae (Lyngb.) Bréb.

Scenedesmus bijugatus (Turp.) Kütz. var. *seriatus* Chodat.

S. acuminatus (Lagerh.) Chodat

Botryococcus Braunii Kütz.

Coelastrum microporum Naeg.

Kirchneriella lunaris (Kirchn.) Meneg.

Polyedrium minimum A. Braun

P. limneticum Borge (Text Fig. 1.)

Cosmarium reniforme (Ralfs) Arch.

Found with zygospores. Zygospores 51–60 μ in length, 742–48 μ in breadth.

C. reniforme var. *compressum* Nordst.

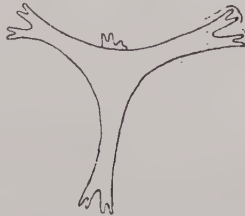


Fig. 1—*Polyedrium minimum*

REVIEWS

Blatter, E. *The Palms of British India and Ceylon*: Oxf. Univ. Press (1926). This is in part a reprint of a series of papers by the author, published in the Journal of the Bombay Natural History Society between 1910 and 1918 under the title "The Palms of British India and Ceylon." The whole has, however, been revised and added to by the author.

The book is well illustrated with excellent photographs, 42 of which were taken in the Peradeniya Gardens, and which give a very good idea of the habit of the palms represented.

Unfortunately some of the photographs, appear to be wrongly labelled. Thus in plate 32 the *Livistona* is the centre palm, 36 is *Latania Loddigesii* Mart. rather than *L. Commersonii*, 72 is *Oreodoxa regia* Kunth.

In addition to the photographs the author has written a botanical description of each species dealt with and has collected together many interesting details about the economic products of Indian palms. He adds an excellent Bibliography.

A. H. G. Alston.

Tansley, A. G. and T. F. Chipp—Aims and methods in the study of vegetation. *The British Empire Vegetation Committee and the Crown Agents for the Colonies*, London (1926).

This gives an account of methods of studying vegetation and is intended to form a Handbook of Ecology for botanists throughout the Empire. The book is divided into three parts. Part I is concerned general ecology and methods of work, Part II deals with methods of work that have been found useful and different parts of the Empire and Part III consists of more specialised articles by practical workers. These are also chapters by specialists on certain groups of Cryptogams which require special methods of study.

A. H. G. Alston.

EDITORIAL NOTE

The Annals of the Royal Botanic Gardens, Peradeniya, while retaining its present title, will, from Volume IX, form Section A (Botany) of the Ceylon Journal of Science. Although the Annals will appear in future in this new form, there is no break in the series, and no change editorially or in other essential respects.

It is particularly requested, therefore, that all gifts of literature which hitherto have been made to the Department of Agriculture, Ceylon, in exchange for the Annals should still be continued. All communications with regard to exchanges or any matter arising out of the present publication should be addressed to

**The Director of Agriculture,
Peradeniya, Ceylon.**

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